New England Water Works Association
ORGANIZED 1882

VOL. LIX DECEMBER, 1945 No. 4

This Association, as a body, is not responsible for the statements or opinions of any of its members

APPLICATION OF MAGNESIUM FOR CATHODIC PROTECTION

BY F. M. RUFFING*

[*Read September 11, 1945.*]

CATHODIC protection was first introduced in the year of 1823 by Sir Humphrey Davy as a means of protecting the copper sheathing used on the wooden ships of his day. Fundamentally it is his basic idea that is in use today. Technical advances in cathodic protection have been made in recent years, and its foremost use has been for the control of highly damaging corrosion of buried structures. It has been in this field that the most interest has been shown.

Corrosion of pipe lines and metal structures buried in the ground is caused by the flow of direct current from the metal into the surrounding soil. As the current leaves the metal, it carries away minute particles or ions. This current originates from two different sources: stray current and galvanic current.

Stray current picked up from an electric railway system is a direct current which is one of the basic causes of corrosion by electrolysis in cities, towns, and thickly populated areas. Alternating current used for home, commercial, and industrial consumption has not been known to be conducive to corrosion.

Galvanic current may be caused when a new service pipe is connected to an old rusty main. Current will flow from the new pipe in to the surrounding soil (electrolyte) and to the main, returning to the new pipe at its junction with the main. Other causes of galvanic current are: (1) cinders in the surrounding soil, or coming in contact with the metal; (2) non-homogenous areas on the surface of the metal; (3) use of dissimilar metals such as copper tubing being coupled to steel pipe; and (4) dissimilar soils along a pipeline. Vari-

*The Dow Chemical Company, New York, N. Y.

ous types of soil may be encountered along the right of way, and a pipe line may pass through several horizontal strata of soil when it is raised or lowered to avoid obstacles such as highways, rivers, and railroads. In conducting a soil survey of a pipe line, it is found that distinct changes in the pH value of the soil are not uncommon. The spot where the current leaves the pipe line and enters the soil is referred to as an anodic or corrosive area. The spot where the current leaves the soil and enters the pipe line is referred to as a cathodic or protected area. See A and B in Figure 1.

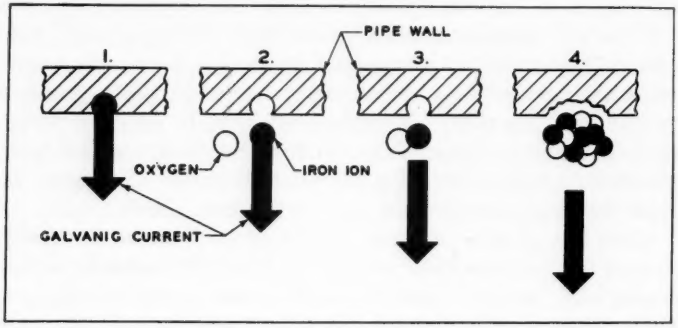


FIG. A

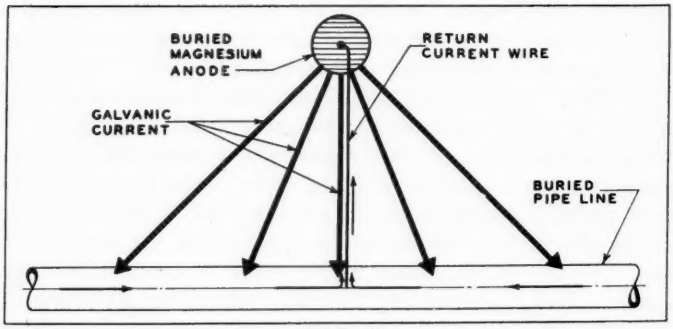


FIG. B

FIG. 1.—CORROSION AND CATHODIC PROTECTION OF PIPES.

Cathodic protection can be accomplished by a galvanic anode with a potential and a current capacity high enough to neutralize the anodic areas on the metal to be protected. Magnesium has several properties that recommend its use as an expendable anode for cathodic protection of pipe lines and other underground structures. Theoretically, it has an electro-chemical equivalent of 1,000 ampere-hours per pound and a solution potential to a $CuSO_4$ electrode of from 1.7 to 1.6 volts depending on whether commercially pure or alloyed material is used. By comparison zinc has an electro-chemical equivalent of 372 ampere hours per pound and a solution potential of approximately 1.1 volts.

In view of these properties, tests were started by the Dow Chemical Company several years ago to determine how magnesium anodes would perform under actual field conditions. The earliest field installations were made using either cast or extruded rods of magnesium of ordinary commercial purity. These early tests quickly demonstrated that magnesium possessed both possibilities and limitations for this type of application. The current output was ample for good cathodic protection, and there was no evidence of polarization, but the operating efficiency fell far short of the theoretical output of 1,000 ampere-hours per pound. Since then a program of research has been carried out to determine how magnesium anodes can be made to perform more efficiently and how their life can be extended in field applications.

One of the first applications using magnesium for cathodic protection of a pipe line was made in 1940 by a consultant for the Dow Chemical Company. Cathodic protection was applied to 41.5 miles of 8-in. gas line. The line was painted with coal tar enamel, and a 15-lb. felt wrapper was used. This being a well coated pipe line, a very small amount of magnesium was needed to achieve complete protection. Commercially pure magnesium anodes 1.3 in. in diameter and from 6 to 10 ft. in length were used. Twenty of these anodes were distributed throughout four stations along the line. The current output per station ranged from 0.8 to 3.6 amperes with the total current drain being 6.25 amperes. A backfill of lime slurry was used in the installation of these anodes. Use of this type of backfill has

since been discontinued, as the current efficiency was only about 30% with very irregular pitting on the surface of the anodes.

In April 1944, the gas lines department of the Dow Chemical Company at Freeport, Texas, applied cathodic protection to 20 miles of 8-in. gas line which had been in service for 3 years. This was considered a well coated line as it was mechanically protected with a coal tar enamel and a 15-lb. felt wrapper. Fourteen-pound magnesium alloy anodes were used. Installations were made at the gate valve stations to eliminate uncovering the pipe to connect the bonding wire from the anodes. At each station sufficient anodes were installed to give a minimum pipe-to-soil potential of one volt. Due to the soil resistivity and the condition of the pipe coating in and around the area, the number of anodes required varied from 5 to 20. In making the installation at the various stations along the line, the anodes were spaced on 2-ft centers, 2 ft out from the pipe with the top of the anodes at pipe depth. In bonding the anodes to the pipe, a No. 4 insulated copper wire was used. As a matter of convenience, a connection in the wire was made above the ground so that an ammeter could be used to check the flow of current periodically. A backfill of sodium chloride was used around these anodes. A pipe to soil potential survey, conducted over the entire line upon completion of the installation, showed that the anodes were properly spaced and sufficient in number to bring the pipe-to-soil potential to a point where protection was achieved. During August 1944, or four months later, a drop in protection was noted. This was found to be due to a change in the moisture content of the soil, raising the resistivity or lowering the conductivity. By November of the same year, the current drain had dropped from the initial 6.6 amperes to 4.82 amperes and was expected to remain at that output until sufficient moisture returned to the soil. The soil through which this pipe line runs consists mostly of a heavy clay having a pH range of from 6.4 to 10.8 and a resistivity of from 50 to 1296 ohms per cubic centimeter in place.

At the Dow Chemical Company's Freeport plant, sea water is the source of raw material and the manufacture of magnesium and bromine. A flume 20 ft wide and 2330 ft long, constructed of bare steel piling, is used to convey the sea water into the plant. As this

flume is of vital importance, its rate of corrosion is a very serious problem. In order to lengthen the life span, various methods of cathodic protection were taken into consideration. Of these the use of magnesium proved to be the lowest in cost. Therefore, it was used. Magnesium alloy anodes, 4 in. in diameter and 18 in. in length, weighing 14 lb, were installed both on the soil and sea water side of this structure. Their installation was based on a current requirement of 3 milliamperes per sq ft. By applying this type of cathodic protection, the life of this structure was extended from an anticipated 5 to an estimated 40 years. The experimental knowledge derived from this installation will be of great value, as various types of backfill were used around the anodes. These anodes will be checked from time to time as a means for determining which backfills give the highest current efficiency. Valuable data on the performance of magnesium anodes in sea water are also being collected.

Laboratory and field experiments indicate that the efficiency and life of a magnesium anode are largely dependent on three factors: (1) the composition of the metal used; (2) the electrolyte used around the anode; and (3) the current density at which the anode operates. On any operating magnesium anode two types of corrosion may be distinguished. The first type results from the current furnished by the anode for the protection of a remote cathode such as a pipe line. This is termed useful corrosion. The second type represents current supplied by the magnesium to protect local cathodes in and on the magnesium anode itself. This is called local or non-useful corrosion, since it consumes the magnesium metal without accomplishing any useful purpose. The ratio of useful corrosion to local corrosion determines the operating efficiency of the anode.

Laboratory experiments have indicated that the rate of local corrosion is a variable which depends upon the composition of the anode and the operating current density; also upon the composition of the electrolyte.

Composition of Anodes. A special DOWMETAL magnesium alloy has been developed to give a very high electrical efficiency when used as an expendable anode. As the rate of local corrosion of the anode is the determining factor in obtaining a high current efficiency,

this must be kept at a minimum. In order to do this, iron and nickel must be kept at a maximum of 0.003% as they are the worst offenders. The composition limits of this alloy are:

Ingredients	*Composition %*
Aluminum	5.3 to 6.7
Manganese, minimum	0.15
Zinc	2.5 to 3.5
Silicon, maximum	0.3
Copper, maximum	0.05
Nickel	0.003
Iron	0.003
Other impurities, maximum	0.3
Magnesium	Remainder

Size and Shape of Anodes. Two anode sizes are available from the Dow Chemical Company as follows:

Type 1A—A cylinder 4 in. in diameter and 20 in. long, weighing about 16 lb (Figure 2).

Type 4A—A "D" shaped rod 4 in, across the flat surface and 60 in. long, weighing about 55 lb.

Both of these anodes include a central ⅛-in. galvanized steel pipe extending about ¾ in. through one end. A No. 14 gauge, single-strand, insulated copper wire 10 ft. long is connected to the pipe and insulated with a natural asphalt.

Anode Ratings. The 20-in. anode is rated at 8,000 ampere-hours. when operating at 50% efficiency. The 60-in. anode is rated at 23,500 ampere-hours when operating at 50% efficiency.

Anode Life. The 20-in. anode can have a life of approximately 10 years if it is operated at a current output of 90 milliamperes or less, provided that an efficiency of 50% is realized. The 60-in. anode can have a life of approximately 10 years if it is operated at a current output of 270 milliamperes or less provided that an efficiency of 50% is attained.

Backfills. To obtain high anode efficiency and anode life the following backfills are suggested:

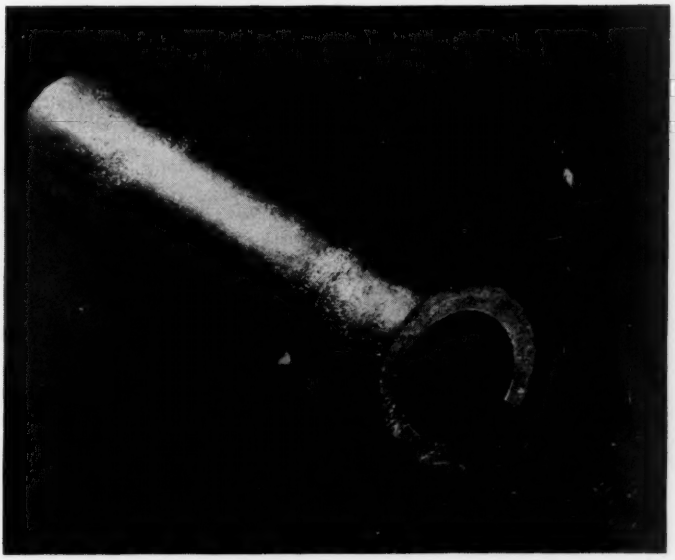


FIG. 2.—DOWMETAL ANODE—TYPE 1A.

(1) *For Low-resistance Soils*
3 parts Aquagel (bentonite)
1 part ground gypsum, hydrated ($CaSO_4.2H_2O$)

(2) *For High-resistance Soils*
2 parts Aquagel (bentonite)
1 part anhydrous sodium sulfate
1 part ground gypsum, hydrated ($CaSO_4.2H_2O$)

Experimental laboratory data now indicate that efficiencies of 50% are attainable in the first backfill, but that the efficiency will be somewhat lower in the second backfill. The materials are inexpensive and are readily available on the open market.

Visual confirmation of the action of Aquagel in controlling the corrosion of the anodes is shown in Figure 3. Examination of this cross sectional view of anode No. 3 in Aquagel (Bentonite) shows that the filler maintains a relatively homogenous mixture of magnesium salts around the anode.

FIG. 3.—CROSS-SECTION OF ANODE IN BACKFILL.

Preparation of Backfill. The backfill can be made up by mixing the ingredients with water until a thick but pourable slurry is obtained. If ground, hydrated gypsum is not available, ordinary gypsum plaster may be used provided that it is properly mixed with the Aquagel. Backfills containing Aquagel or bentonite should always be installed as a wet mud, because the wetting characteristics are so poor that it may take months before the anode commences to operate if the dry backfill is tamped around the anode. Likewise hydrated sodium sulfate, $Na_2SO_4.1OH_2O$ (Glauber's salt) may be substituted for the anhydrous sodium sulfate specified above where the latter is not available. Where the hydrated sodium sulfate is used, about twice as much is needed.

If pure magnesium anodes are used, or, if the installation is made in acid soils (bog or peat marsh) it is desirable to include magnesium hydroxide, $Mg(OH)_2$, in the backfill compositions. This is done by mixing 4 parts of backfill with 1 part of dry magnesium hydroxide. The inclusion of magnesium hydroxide serves to reduce metal efficiency losses, due to acid attack.

Installations. A typical magnesium anode installation is shown in Figure 1.

The installation is made by boring a 6-in. hole in the earth adjacent to the pipe line or other underground structure to be protected, using a post hole digger or soil auger. The hole should be deep enough so that the top of the anode is at least as deep as the bottom of the pipe. Where soil resistivity data are available, an attempt should be made to locate the anode in the most highly conducting soil strata. Other things equal, this usually requires that the anode be deep enough to reach permanent soil moisture.

Fill hole to a depth of about 4 in. with prepared backfill, and place anode in hole. Fill to a depth of about 4 in. above anode with more of prepared backfill. Anode should be installed so as to be centered within the hole. Backfill the remainder of the hole with earth.

Attach the other end of the lead wire to a steel lug, and arc-weld the steel lug to the exposed pipe line. Insulate the lug and connection with pipe-line dope. Trench-in the lead wire to below cultivation depth wherever necessary.

Spacing of Anodes. A distance of 10 feet from the structure may be satisfactory in many instances. However, in establishing the most desirable distance between the anode and the structure the following factors must be taken into consideration: (1) condition of metal surface (for instance—is the metal bare or coated?); and (2) resistivity of the adjacent soil.

No definite recommendations can be given for distributing anodes along a pipe line or around a structure, inasmuch as each installation will require its own investigations. In general, the distributions will depend largely upon whether the pipe is bare or coated, and also upon the conductivity of the soil. On well-coated lines traversing high-conductivity soil, the spacing between anodes or anode stations may range up to several miles. The other extreme is realized on large bare lines buried in high resistivity soil where anode spacings 50 feet apart may be required.

To date, the experimental program of the Dow Chemical Company on the use of magnesium for cathodic protection has been limited almost entirely to pipe lines. This has been due to labor and

war-time working schedules. As soon as conditions permit, a more diversified program of research on cathodic protection is planned. Mitigation of corrosion in hot water tanks, stand pipes, and other water works structures is included in this program. These tests will be conducted both in the laboratory and in the field and should prove to be of great importance and value to both the distributor and consumer of water. The information obtained will be released by the Dow Chemical Company as it becomes available.

PRESTRESSED REINFORCED CONCRETE PIPE

BY F. F. LONGLEY*

[*Read September 11, 1945.*]

A discussion of prestressed reinforced concrete pressure pipe needs a certain perspective. It can be very well introduced by relating a series of steps in the development of reinforced concrete pressure pipe that have had their part in leading up to present-day design.

No great ingenuity or skill is necessary to build two concentric forms of short length and pour concrete between them, thus forming a concrete pipe. That was no doubt the beginning of the concrete pipe industry. No great ingenuity or skill, furthermore, is needed to place a cage, made of steel, between these forms and thus produce a short reinforced concrete pipe. At the beginning of this century, that was about the state of the art in this country. Concrete pipe and reinforced concrete pipe were being made and used, with growing appreciation of their merits, and also with growing accumulation of helpful facts regarding design and the supporting capacity of this pipe for external loads. The field of usefulness for concrete pipe at that period was mainly the construction of gravity sewers, drains, and culverts. The idea of using it for the construction of pressure pipe lines was at that time only in a budding stage. There is evidence that Europe was a little ahead of the United States in the development of reinforced concrete pressure pipe, as early installations in the city of Paris were made in the early 1890's.

In 1909, the city of Toronto commenced to build a filtration plant of the slow sand type. This called for the use of 5,000 or 6,000 lineal feet of 72-in., 54-in., and 36-in. conduit to carry water to and from the filters and the reservoir. These conduits were to operate under slight internal pressure. It was not much, but enough to class this work definitely as a light-head pressure pipe.

The writer was resident engineer on that work. The city's engineering advisers were well impressed with the arguments favoring

*Lock Joint Pipe Company, East Orange, N. J.

the use of reinforced concrete pipe for this purpose, and after some study the decision was reached to use it, and an order was given to the Lock Joint Pipe Company for this pipe. The concrete pipe that could be furnished at that time was what would now be classed as sewer pipe. The utmost pains were taken in the laying of this pipe and in the making of the joints. The plant was put in operation, and these light-head concrete pressure pipe lines were entirely successful and have operated without trouble through a third of a century. It is logical to refer to this construction as one of the steps in progress towards the highly effective pressure pipe of today.

A few years later, the water supply board responsible for supplying water to the cities of Salem and Beverly, Mass., had a project which involved a force main to carry some of the flood waters of the Ipswich River into Wenham Lake. Malcolm Pirnie and the writer were associated on the engineering work, and with a conviction that a conduit of concrete would be effective, a contract was awarded for the construction of this force main with reinforced concrete pipe, which again was furnished by the Lock Joint Pipe Company. This Salem-Beverly pipe line was partly 48 in. and partly 36 in. in diameter and was designed to operate under a head, near the pumping station, of about 20 ft. The water was delivered through it by electrically-operated centrifugal pumps. The line was put in operation and has served well ever since.

Here, then, are two early instances in which the writer was the engineer and the Lock Joint Pipe Company the furnisher of reinforced concrete pipe to operate under internal pressure. I think I am safe in saying that all those involved in these jobs gained a vivid impression of the possibility of developing a very effective type of reinforced concrete pipe for construction of pressure pipe lines. This thought was coming home to the Lock Joint Pipe Company with special emphasis.

These early jobs, of course, were for light pressure. No one at that time would venture to build concrete pipe lines for high pressures. But the seed was now well planted. Other opportunities came quickly and along with them came a realization of shortcomings, one of the chief of which was the joint. In the pipe then being made, which today one would refer to as sewer pipe, having concrete surfaces at

the ends, the only way to make the joint was by filling the joint space with cement mortar.

This could be done fairly effectively, under the right conditions, if the utmost precautions were taken, and with the highest type of workmanship, as witness the success in the two cases that have been cited, in which the greatest pains were taken to produce good, tight joints. Such a mortar joint cannot be made well if the concrete is too dry, nor if it is too wet; nor can it be made well if the concrete is too hot, nor if it is too cold. For quantity production under the average field conditions, the mortar joint placed against concrete surfaces left a great deal to be desired and could not be relied upon for a satisfactory degree of watertightness.

Such considerations resulted in the pipe joint coming in for a lot of attention at an early date, and in due time this problem was solved and the joints now in use by the Lock Joint Pipe Company, which are today so well known to water works engineers, constituted a major improvement, and formed an exceedingly important factor in the development.

In addition to the pressure joint improvements just referred to, carrying capacity has been the subject of much study and various improvements have been made, so that the carrying capacity of our pipe lines up in the very highest range can be confidently predicted. Economy is a topic for constant study, and the number of improvements that have been made for better economy is very large. Unfortunately, at present, labor cost has risen sharply again, due to increased labor rates, labor shortages, and the numerous labor difficulties with which we now have to struggle. Ability to carry external loads comes into many a problem, and various improvements have been made with a view to bringing that feature to a high degree of perfection.

With these and many other improvements over the past thirty years or so, it is evident that the Lock Joint Pipe Company believes thoroughly in a constant effort to improve its products; and notwithstanding the fact that scores of pipe lines built in the past decade or so, for the most vital service and for the most discriminating engineers, have given complete satisfaction, and might therefore be considered to be perfect, this company has kept ever before itself a

high goal of perfection, and the development of prestressed pipe is one of the natural results.

Let us not think of prestressed pipe as something new. The principle of prestressing steel in tension and concrete in compression is old and well known, but it can be said that the application of this principle to the manufacture of pipe is quite recent. The reason for this is, no doubt, that only recently have effective methods and equipment been devised to produce prestressed pipe satisfactorily and economically. There are a great many patents reposing in the archives of the Patent Office, relating to the prestressing of steel in tension and concrete in compression. Many are so old that they have expired. Notwithstanding that, the examples of engineering structures involving this principle are few in type and few in number, and until quite recently, none at all in the field of pressure pipe manufacture.

Today, prestressed pipe is being made and used with entire success. The Lock Joint Pipe Company, as well as others, have devoted years of time and much patient effort to the development of commercially feasible methods for its manufacture. And again let me emphasize that we do not need to regard it as something new and therefore of doubtful efficacy. All the essential elements of old and well proved pipe design are there; the steel cylinder (excepting in pipe for the lighter range of pressures), the joint rings and gasket, well known and well proved, the cage of steel supplementing and surrounding the steel cylinder, and the dense, rich concrete envelope within and without. The improved feature is merely that the cage is made of steel wire of high tensile strength instead of steel bars or rods of normal structural strength, and this wire is placed in the wall of the pipe under a high initial tension, with a consequent initial compression in the part of the pipe wall lying inside of the tensioned wire.

One reason, we have gathered, why some prospective customers have shown some reluctance to adopt prestressed pipe, is that they suspect that dimensional changes can occur in the core which might result in a reduction in the length of the prestressed circumferential wire, and a consequent loss of some of the initial wire stress. Dimensional changes can, of course, occur in the core, although they are admittedly of only microscopic magnitude. The first point to make

in this connection is that even if these small dimensional changes do occur, without anything being done to counteract their effect, the bursting strength of the pipe will not be affected (as is referred to later on), and the main effect would be that the range of internal pressure, within which the pipe would behave as a true elastic structure, would be less. The second point to make is that both in European practice, which we have investigated, and in our own practice, the possibility of these microscopical dimensional changes in the core is recognized, and measures are taken to anticipate this and to counteract its effect by boosting the stress at the moment of winding the wire to the extent of something like 20% over the stress computed to meet the design conditions.

Lock Joint prestressed steel cylinder pipe is made as follows: The welded steel sheet cylinder, with joint rings attached, is made and tested under internal water pressure, just as we have done for years in the manufacture of steel cylinder pipe. The cylinder is then lined with concrete to a pre-determined thickness. This may be done either by casting in a vertical mold, or spinning centrifugally. This lined steel cylinder constitutes the "core", and after curing is ready for the tension winding. The core is rotated in a machine and the wire wound upon it helically. The end of the wire is held firmly attached to one of the joint rings, and the wire is under a constant and uniform tension, fixed by the conditions of design. The movement of rotation and of axial translation are under mechanical control, and can be fixed to meet the conditions of design. Where the helix terminates on the other joint ring, the wire is again firmly attached. See Figure 1.

The pipe is now complete except for the outer envelope of cement mortar. The pipe is rotated and the coating machine is moved longitudinally in front of it. The mortar, premixed and very low in water content, is now hurled against the outer surface of the pipe at a velocity of about 80 feet per second, building up a remarkably dense and resistant envelope to a depth of ¾ in. The pipe is then again placed in curing bins.

Continuing the thoughts previously expressed regarding "improvements", it is pertinent to remark that the several essential steps in the manufacture of prestressed cylinder pipe, especially the making

FIG. 1.—MANUFACTURE OF LOCK JOINT PRESTRESSED REINFORCED CONCRETE PIPE. At the left is the concrete-lined core; at the right the same with wire wound under tension on half its length.

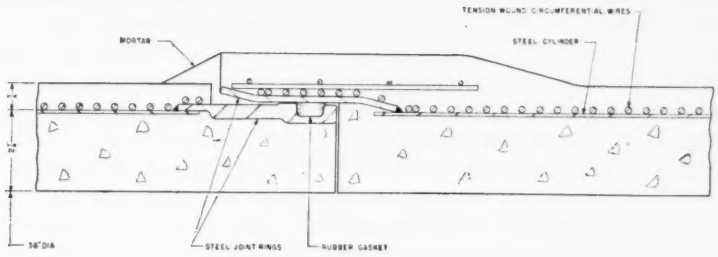
of the cores, the stress-winding of the wire, and the production of the envelope of cement mortar, required special machinery, all of which we developed ourselves and constantly studied and improved to assure a high degree of efficiency and dependability.

For most of our pipe lines of prestressed pipe, we prefer to make the pipe with a steel cylinder. In view of the fact that some pipe lines have been built recently of prestressed pipe without a steel cylinder, it seems worthwhile to develop this idea somewhat. Let us consider for a moment the pipe we have been making for years, not prestressed. We have built endless miles of steel-cylinder pipe lines for pressures ranging as high as 250 psi and have been able to sleep nights with little or no concern about leakage. This we could not have done if we had not built a steel cylinder into the pipe wall. We have also built pressure pipe lines without a steel cylinder. That

was the way we started many years ago. In those early days, the work we were permitted to do was for relatively low heads. We still build pipe lines without a steel cylinder where the internal pressure lies within a limit which is appropriate for the wall thickness and other conditions. Many pipe lines fall within this category, and there is a definite place for non-cylinder concrete pressure pipe. In a large percentage of the water works jobs in this country, however, the operating pressures are high enough to call for the use of steel-cylinder pipe. In a general way, we have been in the habit of thinking of 50 ft to 75 ft as a comfortably safe limit of head for cast pipe, non-prestressed, and without a steel cylinder, influenced to some extent by pipe diameter, wall thickness, etc.

Now let us turn to prestressed pipe. Broadly speaking, it may be said that a steel cylinder should be used in prestressed pipe designed for the higher range of pressures, but that it can be dispensed with in prestressed pipe designed for the lower range of pressures. We had better beg the question at the present time as to what is the pressure limit that divides these two. There is too little evidence from experience to date to serve as a basis for any generalization on this point, and generalizations are rarely safe anyhow.

It may be of some significance to note that, while the highest internal pressure for which we have thus far built a steel-cylinder pipe line, not prestressed, is 250 psi more or less, we can easily build prestressed pipe for twice that pressure. And while we generally limit the internal pressure in non-prestressed pipe without a steel



SECTION THRU JOINT

FIG. 2.—CROSS-SECTION THROUGH JOINT OF LOCK JOINT PRESTRESSED PIPE.

cylinder, to something like 75 ft, there is some evidence that a head limit twice as great as that, or perhaps somewhat higher, would be satisfactory for prestressed pipe without a cylinder.

A prestressed pipe line without steel cylinder was built in Chicago a few years ago and was described in the Journal of the American Water Works Association of October 1943. The operating pressure that this line is intended to serve is stated to be about 37 psi, though it was subjected to a test at 100 psi. This job reflected great credit upon those who built it, and reflected, also, no doubt, a lot of painstaking attention on the part of the pipe manufacturer and a combination of favorable materials and manufacturing conditions. Experience with the manufacture of prestressed pipe without steel cylinder has indicated that it is well suited for pressures up to a medium range, but that there is need for a discriminating judgment as to the limits of internal pressure for which it should be used.

The prestressed pipe we have been building, all of which has been for high pressures, has been made with a continuous watertight cylinder of steel sheets. In the course of fabrication of the steel structure of the pipe, this steel cylinder is tested for tightness in all its welded seams, and we can therefore count upon watertightness of the pipe wall at high pressure. By this means, we can be quite confident of being able to produce a pipe line that will meet every criterion of satisfaction at high pressure.

In pressure pipe that is not prestressed, the use of the steel cylinder fits in with perfect logic, as it is in tension and carries its proportional share of the load. In discussing the design of prestressed pipe, however, we are now and then faced with the question whether the steel cylinder is a logical and necessary feature because it forms part of the compression core of the prestressed pipe, that is, it is under compression rather than tension throughout the customary range of operating pressure.

The answer to this is clearly "Yes"—the steel cylinder is a logical and necessary feature of prestressed pipe for the range of pressures for which it is commonly used. It is a fact that this element of steel is in compression in the pipe as manufactured and ready for use, but when the pipe is full of water and interior pressure is increased, the tension in the steel wire increases, and the compressive

stress in the concrete and in the steel cylinder diminishes. A point is reached in the increasing pressure where the compressive stresses in the concrete and in the steel cylinder are reduced to zero.

So long as any compressive stress remains in the core, the circumferential elongation of the pipe wall under increments of increasing pressure is governed by the combined characteristics of the steel and the concrete, which are firmly and intimately bound together by the prestressing wire. When the increasing pressure reaches a point that causes the compressive stress in the core to be reduced to zero, and passes it, the concrete will have lost its tendency to increase its dimensions further and presumably will lie inert, and from that point upward to higher pressures, the wire and cylinder will both be in tension, and the circumferential elongation of both will then be governed by the characteristics of steel alone.

In discussions of the prestressing principle in technical literature, there are those who have belittled its value on the ground that the prestressing of the elements of a structure does not improve its behavior at the point of failure. Granted that it does not. Thinking in terms of prestressed cylinder pipe, failure occurs when the total load exceeds the total resisting power of the tension elements, that is, of the steel. This, of course, occurs at an internal pressure much beyond that at which any compressive stress remains in the concrete, and beyond that at which the steel cylinder and the wire reach their elastic limits. Obviously, two pipes made with steel of equal total resisting power will reach the point of failure at the same internal pressure even if one is prestressed and the other is not.

The point of failure is not the only factor we are concerned with, nor is it the most important one. We are interested primarily in the behavior characteristics of the pipe within the range of pressures in which it is designed to operate, including an allowance for abnormal pressure rises such as water hammer. If, within that range of pressure, we have a pipe whose circumferential variations in dimensions are governed by identical relationships between stress and strain in the steel and in the concrete, instead of differing relationships, we have a better performing pipe. That is the characteristic of prestressed reinforced concrete pipe. That is the characteristic of a pipe behaving like a truly elastic structure.

It is pertinent to state that the Underwriters' Laboratories have conducted a series of tests on Lock Joint prestressed reinforced concrete pipe made with the steel cylinder, and their report is one of complete approval. The size used in these tests was 42-in. pipe.

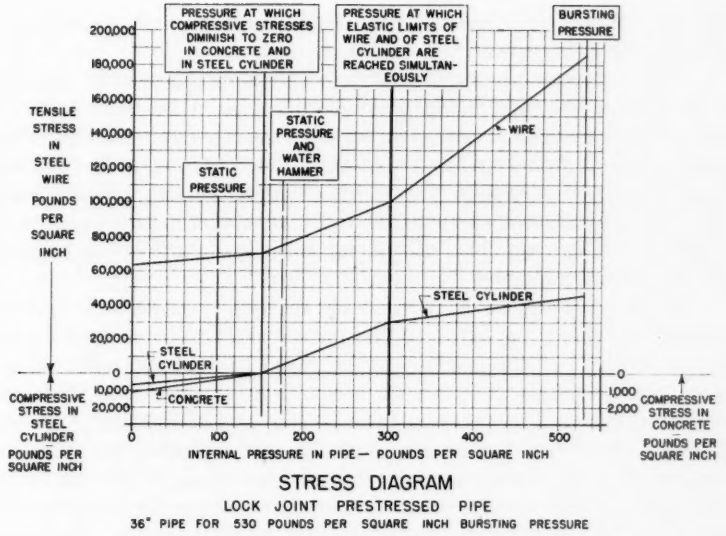
The pipe lines thus far built with this pipe include the following:

Location	Size—in.	Approx. length—ft	Design pressure—psi
Norfolk, Va.	20	22,000	100
Norfolk, Va.	20	13,000	100
Pennington, Va.	20	20,000	300
Washington, D. C.	20	2,500	150
Climax, Colo.	20	2,000	250
Hyattsville, Md.	30	50,000	130
Washington, D. C.	30	14,000	120
Washington, D. C.	30	11,000	150
San Juan, P. R.	36	47,000	200
San Juan, P. R.	42	23,000	110
Bethlehem, Pa.	34	10,000	

In addition to the desirable elastic quality, previously referred to, this pipe is of lighter weight, stronger as a beam, and stronger to resist external loading, than a corresponding design of the older steel-cylinder pipe.

An idea of the stresses in the several elements of prestressed steel cylinder pipe, and of the changes that take place therein with changes in the internal pressure, may be quickly grasped from a study of a typical pressure-stress diagram. (See Figure 3.)

When the pipe is made, the wire is wound under tension upon the outer surface of the core, which consists of the welded steel cylinder lined with concrete. The wire is given a high initial stress and this, of course, induces a compressive stress in the core, in both elements thereof—the concrete lining and the steel cylinder. The product of the area of the wire by its unit tensile stress is equal to the sum of two products, the area of the concrete by its compressive stress, plus the area of the steel cylinder by its compressive stress. In each case where "area" is thus referred to, it means the area of that element in a lineal foot of cross section of one pipe wall, cut by a plane passing through the pipe axis.



STRESS DIAGRAM

LOCK JOINT PRESTRESSED PIPE

36" PIPE FOR 530 POUNDS PER SQUARE INCH BURSTING PRESSURE

FIG. 3.—STRESS DIAGRAM FOR LOCK JOINT PRESTRESSED PIPE.

In the pipe at rest, that is with zero internal pressure, the stresses in wire, cylinder, and concrete are as shown on the vertical line through zero pressure. Here it may again be well to emphasize the point that the three elements—wire, steel cylinder, and concrete lining—being fabricated under stress into a single unit in stress equilibrium, are forced to change their dimensions in identical amounts when subjected to load. Thus, when the pipe is filled with water and the pressure is increased, the elongation of the wire and of the steel cylinder proceed at equal rates, and the two lines representing this on the diagram are parallel. The wire is increasing in its tensile stress, and the steel cylinder is decreasing in its compressive stress, but at equal rates. The concrete, also, is decreasing in its compressive stress, at the same dimensional rate, though at a different stress rate. The stresses in the three elements at any given internal pressure in the pipe may be determined from the equilibrium that exists between the interior water pressure and the then condition of the three ele-

ments, governed by the equilibrium initially established among them when the interior pressure was zero.

As the internal pressure is increased, these closely related changes in stresses in the three elements proceed. A point is reached in the increasing internal pressure when the diminishing compressive stresses in the concrete lining and in the steel cylinder become zero. At that moment, as well as before, the wire is carrying the entire load resulting from the internal pressure, and the core of concrete-lined steel cylinder, having just lost all of its initially induced compressive stress, is for the moment "in neutral".

In testing a pipe to destruction, the internal pressure is, of course, carried way above any pressure that is ever likely to come upon a pipe line in service. If the pressure is increased beyond the point where compressive stresses in the core are reduced to zero, the concrete may be considered as carrying none of the load of internal pressure, which is all carried by the wire and the steel cylinder, both now in tension. The computation of stresses corresponding to internal pressure now becomes simpler, because there is no longer the complicating factor of a diminishing compressive stress in the concrete. The rates of stress-increase in the wire and cylinder are equal and directly proportional to rates of pressure-increase, and the lines representing this relationship on the diagram are parellel.

This continues until the increasing internal pressure reaches a point corresponding to the elastic limit of the wire and the steel cylinder. These are reached simultaneously as one of the conditions of design. The wire, having a much higher elastic limit than the steel cylinder, commences to carry the entire load, accompanied by a ductile yielding or elongation of the steel sheet. Then, as the internal test pressure is carried still higher and approaches the point of failure, the circumferential enlargement becomes conspicuous, and finally, with a sharp report, a number of coils of the tension-wrapped wire pencil out and break. The concrete cover ruptures and comes off in fragments over the area of the broken wire. The steel cylinder, already well beyond its yield point, thus relieved of external support of the wire, bellies out like a balloon.

The lines on the diagram showing the variation in stresses in the steel cylinder and the wire are parallel up to the pressure at which

they both reach their elastic limit. Beyond that they are no longer parallel, but to the point of pipe failure they follow directions governed by their separate physical characteristics.

Reinforced concrete steel cylinder pressure pipe, not prestressed, has long been recognized for its numerous advantageous qualities, its great durability, its high and enduring carrying capacity, its excellent joint and consequent watertightness, and its economy. But prestressing has added considerably to the economy of the pipe and also, in an important degree, to its elastic qualities. In this prestressed pipe we have a pipe that is truly elastic throughout its usual range of pressures, and this is a real advance in the art.

THE COMMUNITY FACILITIES PROGRAM OF THE FEDERAL WORKS AGENCY

BY L. A. GILLETT*

[*Read September 11, 1945.*]

In June, 1933, in the midst of the greatest of depressions, the Congress of the United States authorized the President of the United States to create a Federal Emergency Administration of Public Works and to appoint an Administrator charged with the duty of preparing and executing a comprehensive program of public works both federal and non-federal, including the control, utilization, and purification of waters, the development of water power, and the construction, repair, and improvement of public highways, parkways, public buildings, and any publicly-owned instrumentalities and facilities. It was contemplated that most of the work should be performed by private contractors. In order to furnish jobs for the unemployed quickly, Congress provided an initial appropriation of $3,300,000,000, but the Administrator soon learned that it was impossible both to plan construction and construct quickly for the planning of construction was a big job in itself and took time. It was necessary that surveys be made by engineers, working drawings completed by draftsmen, specifications prepared, cost estimates made. All the usual important work preliminary to construction had to be accomplished before construction itself could even start, with the result that a year and a half passed by before any considerable number of men could be employed on non-federal jobs.

In course of time, the plans were prepared and the Federal Emergency Administration of Public Works (familiarly known as P.W.A.) performed important work in a satisfactory manner, but the hungry and jobless could not wait, and Congress had been forced to create the Works Progress Administration (familiarly known as W.P.A.) in order to provide work relief under a program that, for the most part, put men to work without extensive planning.

*Division Engineer, Bureau of Community Facilities, Federal Works Agency, New York, N. Y.

As Major General Philip B. Fleming, Federal Works Administrator, well said in a radio broadcast not long ago: "'One thing is sure—periodic depressions are just as characteristic of our economy as boom times. We have had dozens of them in the past, and we can expect more in the future. If we have learned the lesson of W.P.A., we will be prepared with plans by which they can be ameliorated."

In 1939, Congress passed a Reorganization Act authorizing the President to group and consolidate certain Executive Agencies. In order to carry out the purpose of the Act, President Roosevelt grouped under the Federal Works Agency those agencies of the Federal Government which dealt with public works not incidental to the normal work of other departments and which administered federal grants or loans to state and local governments or other agencies for the purpose of construction. The agencies so grouped were: the Bureau of Public Roads, formerly in the Department of Agriculture; the Public Buildings Branch of the Procurement Division, formerly in the Treasury Department; the Branch of Building Management of the National Park Service, so far as it was concerned with public buildings which it operated for other departments or agencies, formerly in the Department of the Interior; the United States Housing Authority, formerly in the Department of the Interior; the Federal Emergency Administration of Public Works; and the Works Progress Administration. This did not include the functions of the National Youth Administration. Later on, the Housing activities were administered by a separate agency of the government, the National Housing Administration. The W.P.A. was abolished by Act of Congress, and the P.W.A. substantially completed its work.

Long before Pearl Harbor, the President recognized that the second World War had created an emergency in this country and so stated by proclamation on September 8, 1939. In October, 1940, Congress recognized the need of national defense by passing an act which has become commonly known as the "Lanham Act." Title I of this Act had to do with Defense Housing, the administration of which is now in the hands of the National Housing Administration, and Title II, which is entitled "Defense Public Works," has been and is now being administered by the Administrator of the Federal Works Agency.

By Title II of the Lanham Act, the Federal Works Administrator was authorized, with the approval of the President, in order to relieve acute shortages of public works or equipment for public works necessary to the health, safety, or welfare of persons engaged in national defense and which could not be otherwise provided when needed or could not be provided without the imposition of an increased excessive tax burden or an unusual or excessive increase in the debt limit of the taxing or borrowing authority in which such shortage existed, to plan, construct and equip public works and to make loans or grants to public agencies or to private non-profit agencies for public works and equipment therefor, and to make contributions to those agencies for their maintenance and operation.

By the authority of this Act, the Federal Works Agency, both before and during the war, assisted communities, great and small, which had been over-burdened by the world war impact, by constructing or helping in the construction much needed community facilities such as water works, sewers, schools, recreation buildings, hospitals, and playgrounds.

In order to qualify for assistance under the Lanham Act, there had to be a war-connected need which made it just and reasonable that the Federal Government assume the whole or part of the burden created by the war. For example, if the town of Kittery, Maine, had ample school facilities for its own normal needs and the influx of war workers to the Portsmouth Navy Yard created a need, which might be temporary, for greatly expanded school facilities, it was just and reasonable for the Federal Government to build a school building at Kittery, Maine, and lease it to the town of Kittery for the duration of the emergency. It would have been unjust, indeed, to have compelled the taxpayers of Kittery to provide wholly at their own expense school facilities the need for which was caused by the national emergency. The workers in the war industries at or near Kittery were not working in the interest of the taxpayers of Kittery alone but in the interest of the whole nation.

Under the Lanham Act Program of War Public Works, the usual delay in procuring the necessary plans and specifications for the construction of the projects was eliminated as far as possible by the use of standard government plans which permitted the use of non-critical

material made available under the priority system. This type of construction may not always be desirable in the days of peace which lie ahead.

Now that fighting is over, funds which are appropriated by Congress for the administration of the Lanham Act are no longer available for the construction of post-war projects. Nearly all of the Lanham Act projects in division I. have been completed, but a few are still under construction, including a hospital addition in South Boston.

The Federal Works Agency aided many hard-pressed New England communities by providing or assisting in financing the construction of community facilities which were necessary to fulfill a war need. The total Lanham Act expenditures by the Federal Government in the New England States for the construction of public works amounted to approximately fifteen and one-half million dollars.

Twenty-four projects relating to water works were constructed in the six New England States between July 1, 1941, and the Fall of 1945. These projects are located in eighteen communities, some having more than one project; seven communities in Massachusetts, six in Connecticut, two in Maine and one each in Rhode Island, Vermont, and New Hampshire.

For these twenty-four water projects, except four on which final audits are to be made, but for which I have included our latest estimates, the total cost will be approximately $9,000,000, and of this, total funds contributed by the applicants will amount to more than $1,700,000. All of these projects are in use, serving their purpose of meeting the needs of the war emergency. So far as we are able to learn, all will continue in use to serve the reconversion and future needs of the communities.

One of the most interesting and important water projects consisted of improvements to the Newport, Rhode Island, system. The extensive increase caused by the war in naval operations at Newport created a demand for water greatly in excess of the available supply. The increased demand was met by a project consisting of: the construction of a dam to impound 900 mg and intake structure, a booster station, and pipe lines extending to an existing raw-water reservoir, including a subaqueous line about a mile in length; raising the height

of the dike around an existing reservoir to increase the capacity by 150 mg; the construction of a second dam which added 400 mg to the storage capacity of the system; the construction of a filtration plant with a capacity of 4 mgd; the construction of a covered storage reservoir of 4-mg capacity; and the construction of several long mains of large sizes, including pumping stations and chlorinating equipment. This project is connected to and made a part of the system of the city of Newport. It has been designed to permit future expansion as the city's demands increase.

Other New England water projects presented unusual engineering problems, such as submarine mains in Portland Harbor. Installations of the Portland Harbor defense situated on several islands in Casco Bay were concerned over the adequacy of existing mains. Therefore, additional mains became necessary to meet the military requirements. The War Department issued the necessary permits to the Federal Works Agency to construct approximately 5 miles of subaqueous mains connecting the Portland Water System with the several islands involved.

The first contractor started work on August 20, 1942, which may seem late in the year to begin a submarine job, but the emergency would not permit delay. Winter storms, heavy seas, and bitter cold were part of the ordeal of going ahead at that time of the year. Ledge, encountered while dredging the trench in the bed of the bay, and labor shortages caused the construction to fall behind schedule, but the bulk of the work was substantially completed by the following April.

In all, there were approximately 24,000 ft. of subaqueous mains in depths up to 120 ft. About 10,000 ft. of the main consisted of 12-in. wrought-iron pipe with welded joints, reinforced with 18-in. long sleeves. Cast-iron, heavy-duty, flexible-joint pipe became available and was used for about 9,000 ft. A temporary main 4,500 in. length was of 3½-in. steel, boiler tubing, welded into convenient lengths and connected with couplings suitable for submarine work.[1]

The pipe was coated with grease and wrapped with bituminous-impregnated paper. After welding the wrought-iron pipe into 200-ft lengths, it was floated into place by buoys and then lowered by a

[1]For a detailed description of this work see pages 148 to 162 of this Journal for June 1945.

derrick on a barge into the trench. Flexibility of the lengths permitted the forward end of the previously lowered section to be supported on a float until the succeeding section was completely connected and lowered, except for its forward end which in turn was kept afloat. In that manner all connections were made above water. The cast-iron pipe was laid in sections about 60-ft long and bolted by divers after being lowered into the trench.

On January 1, 1945, by order of the Federal Works Administrator, there was created in the Federal Works Agency the Bureau of Community Facilities, and Mr. George H. Field was appointed as its head with the title of Commissioner. The result is that the Federal Works Agency now consists of three branches or departments, namely, the Public Buildings Administration which constructs post offices and other public buildings of the Federal Government and has charge of the management and maintenance of public buildings owned and operated by the government; the Public Roads Administration which assists the states in the construction of state highways and roads by making grants to the states pursuant to acts of Congress; and the Bureau of Community Facilities which now has charge of the completion of the Lanham Act Program, to which I have already referred, and also is charged with the administration of a new Advance Planning Program. This new program has to do with the planning of community facilities but not with their actual construction.

Upon the termination of hostilities, we have embarked upon a period of adjustment, of change from war to peace, which is the prelude to a new era. Congress looked forward to this adjustment period when in 1944 it enacted the "War Mobilization and Reconversion Act" of that year. Title V of that Act is entitled "Public Works" and authorized what I have called the new advance planning program.

We have seen that the obtaining of necessary plans for construction usually entails long delay, and it is a matter of common knowledge that under normal circumstances in peace time, when haste is not necessary, the cost of plans and specifications is usually included in the construction cost and financed as a part thereof. Otherwise, most communities would have no money available with which to put architects and engineers to work. We also know that it is entirely possible that during the critical reconversion period it may be neces-

sary to proceed promptly with a public works construction program in order to prevent mass unemployment. Congress had all of these facts in mind when it enacted Title V of the War Mobilization and Reconversion Act, for this statute was intended to make it possible to have working plans and specifications for public works available for immediate use in case the need arises.

The statute provides that in order to encourage states and other non-federal public agencies to make advance provision for the construction of public works (not including housing) the Federal Works Administrator is authorized to make, from funds appropriated for that purpose, loans or advances to the states and their agencies and political subdivisions to aid in financing the cost of architectural, engineering, and economic investigations and studies, surveys, designs, plans, working drawings, specifications, procedures, and other action preliminary to the construction of such public works.

It is provided that funds appropriated for the purposes of the statute shall be allotted in the following proportion: 90 per cent in the proportion which the population of each state bears to the total population of all the states and 10 per cent according to the Administrator's discretion, provided that the allotments to any state shall aggregate not less than one-half of one per cent of the total funds available for allotment.

The obligation to repay advances made under the statute is purely contingent in character, for the statute states that such advances shall be repaid if and when the construction of the public works planned is undertaken.

In the fall of 1944, President Roosevelt recommended that 75 million dollars be appropriated for advance planning under the act, and 17½ millions were finally appropriated, with the result that it was possible to allot only the sum of $1,038,000 for the six New England States, in accordance with the formula prescribed by Congress. The allotments, in round numbers, made for the different New England States were as follows:

Maine	$ 96,000
New Hampshire	85,000
Vermont	85,000
Massachusetts	492,000

Rhode Island	85,000
Connecticut	195,000

In a little over two months after we started to administer the planning program, more than 100 applications for advances were received from municipalities in the New England States for all types of public work. More than 30 were approved in the State of Massachusetts alone.

It may be of interest to list the projects that have been received to September 1945, providing for improvements in the water supplies or systems in the New England States:

Clinton, Maine	Complete new water system	$111,000
East Longmeadow, Mass. (2 projects)	Standpipe, pumping station, and water main extensions	72,000
Williamsburg, Mass.	Extensions of existing mains	35,000
Williamsburg, Mass.	New standpipe and extensions to existing mains	28,000
Mendon, Mass.	Complete new water system	154,000
Wenham, Mass.	Complete new water system	338,000
Upton, Mass.	Complete new water system	207,000
Concord, N. H.	Addition to supply	600,000
Tiverton, R. I.	Complete new water system	318,000
Montpelier, Vt. (4 projects)	Two new reservoirs; raise dam at a third reservoir; new filtration plant	370,000
	Total	$2,233,000

The Bureau of Community Facilities cooperates with various state authorities having jurisdiction over proposed projects and only worthwhile projects are approved.

It soon became apparent that the amount of money made available would be insufficient to fill the need, and the Commissioner has for that reason been unable to approve all applications of merit. Whether additional money will be available rests with the Congress which is now in session. In his message of September 6, President Truman said that he would request additional funds in order to speed up this important activity during the reconversion period. Procedure has now been well established. A good start has been made, and the Bureau of Community Facilities will be in a position to render speedy and efficient service if Congress shall decide to enlarge the present planning program to supplement private planning now under way so that the country may be better prepared to meet an emergency.

PREDICTION OF FROST PENETRATION

BY WILLIAM L. SHANNON*

[*Received October 19, 1945.*]

Prediction of frost penetration is an engineering problem of common occurrence and considerable importance. The usual approach to the solution of this problem is by experience or by reference to reported observations (1). The most frequent and perhaps the most important application of frost penetration predictions is in connection with the laying depth of water mains and other utilities that are susceptible to damage by freezing ground temperatures.

Using past experience or reported observations for determining the depth of frost penetration may be questioned for the reason that the values available are not generally the results of systematic observations and analyses. Furthermore, structures or developments may be at locations where empirical knowledge has not been gathered. The method may be compared with the early determination of culvert sizes and reservoir spillway capacities in which the largest flood of record was used as the criterion regardless of the length of record or its accuracy. The occasional reports of frozen water mains, washed out culverts, and overtopped dams are proof of the hazards involved in this type of analysis.

Factors Influencing Frost Penetration. The factors that influence the depth of frozen soil, assuming that the soil freezes without increase in its water content during the freezing process, are as follows:

(a) The magnitude and duration of air temperatures below freezing.
(b) The thermal properties of the soil, including its surface.
(c) The temperature conditions within the soil at the start of and during freezing.

The Freezing Index. A method for measuring the combined magnitude and duration of air temperatures below freezing was first

*U. S. Engineer, Office, Boston, Mass.

suggested by A. Casagrande in 1929 (2) and since used also by other investigators (3) (4). This method consists of plotting the cumulative departures of temperatures from 32° F, as shown in Figure 1.

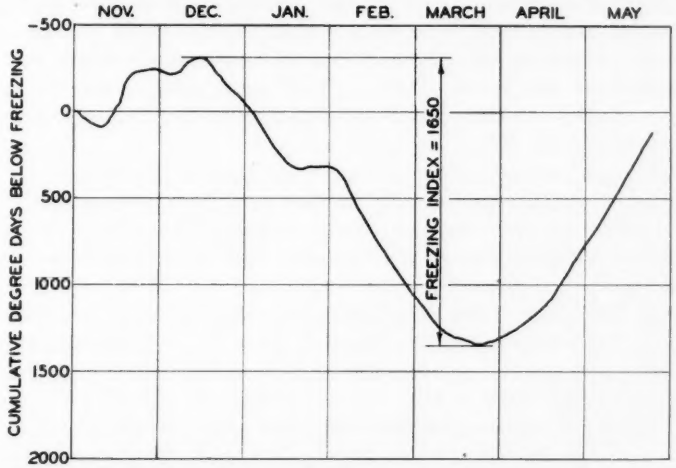


FIG. 1.—FREEZING INDEX COMPUTED FROM CUMULATIVE DEPARTURES OF DAILY TEMPERATURES FROM 32° F.

The cumulative temperature diagram is based ordinarily on the differences between the daily mean temperatures and 32° F. These differences are summed consecutively commencing with the first day in the fall or early winter on which the mean temperature drops below freezing. Differences for days when the average temperature lies above 32° F are assigned negative values. Thus, the first portion of the cumulative diagram may consist of predominately negative values. The differences between the largest negative value and the largest positive value on this plot is termed the "freezing index", as shown in Figure 1. It is a combined measure of the magnitude and duration of below-freezing air temperatures. The greater its magnitude, the greater will be the frost penetration, other factors being the same.

An approximate value for the freezing index may be computed from the monthly average temperatures using the following formula:

Freezing Index $= (32y - x)$ 30.2 in which y equals the number of months during which the average temperature is less than 32° F, x is the sum of the average temperatures for these months, and 30.2 is the average number of days for the months of December, January, February, and March. The value computed using this formula will *always be less* than the true index but will approach it with increasing magnitude of the freezing index. This approximate method should not be used at locations where the mean value for the freezing index is less than about 300.

Thermal Properties of Soils. The thermal properties of soils have as yet not been extensively studied, and most investigators have been primarily concerned with these properties in the dry state, a condition which is seldom encountered. One investigation has been reported by the Department of Agriculture (5) in which moisture content and density were considered as variables. Further, the thermal properties of frozen soil are different from those of unfrozen soil. Experimental results showing this difference have been reported by Berggren (6).

The temperature conditions within the soil at the start of freezing will influence the depth of frost penetration. Soil temperatures near freezing will result in deeper penetration than soil temperatures that are warmer. Investigations of soil temperatures by the U. S. Engineer Department are now in progress at a number of selected locations beneath pavements at Army Air Corps airfields. The results of these observations when completed should be of assistance in the analysis of frost penetration.

An additional factor influencing the depth of freezing is the nature of the surface layer. A dark-colored surface layer will absorb a maximum of heat from solar radiation on sunny days and will give off a minimum of heat by radiation at night or on cloudy days. A light colored surface, on the other hand, will absorb a minimum of heat from solar radiation and will radiate a maximum of heat at night or on cloudy days.

Grass cover, leaves or snow may possess sufficient insulating qualities to reduce the depth of freezing to a small fraction of the depth of freezing beneath a paved surface that is maintained free of snow.

Depth of Frost Penetration. The depth to which soil freezes has been studied and a rigorous solution developed by Berggren (6). His solution takes into consideration the different variables but assumes that the moisture content of the soil will not change during the freezing process, *i.e.* that the amount of ice segregation as a result of frost action will be limited by the water available within the voids. Berggren's equation for frost penetration may be written as follows:

$$x = 2B\sqrt{ta}$$

in which x = frost penetration; t = time that the air temperature is less than the freezing point of soil; a = thermal disfusivity of frozen soil $= \frac{\text{thermal conductivity}}{\text{heat capacity}}$; and B is a function of: (a) the thermal properties of soil, *i.e.* thermal conductivity and heat capacity; (b) temperature conditions of air and soil; and (c) latent heat of fusion of water in soil.

Using Berggren's equation, it is possible to compute values for frost penetration x corresponding to values of the "freezing index" for a given set of conditions. The writer has made one set of computations using this procedure to determine the shape of the curve relating freezing index and frost penetration. These computations indicate that the relation is represented on a log plot by a very flat curve which may be approximated by a straight line.

Unfortunately, the application of this equation to the prediction of frost penetration directly is impractical at the present time because we are not sufficiently familiar with the thermal characteristics and temperature conditions of soil and the effect of the surface boundary upon the penetration. Computations made by the writer based upon known conditions indicate that Berggren's formula yields frost penetrations that are greater than measured values by approximately 50 per cent.

As indicated by Berggren's equation, the depth to which soil will freeze will depend upon the thermal conductivity and heat capacity of the moist soil and upon the latent heat of fusion of the water in the soil, all other conditions being equal. A study of the test data for thermal conductivity (5) indicates that cohesionless sands and

gravels have a greater thermal conductivity than any other soils studied, including silt, clay, and peat. This conclusion is substantiated by tests performed by the Boston District, U. S. Engineer Department, under the supervision of the writer. The specific heat of dry soils has been found to be constant for practical purposes, hence the value of the heat capacity of soil varies directly with its unit weight and water content. Likewise, the total latent heat of fusion of the water in the soil varies directly with the water content of the soil.

Proceeding from these general observations, it may be concluded that, under the same conditions, the depth of freezing would be greatest in dry or moist sand or gravel and that the depth of freezing in all other soils would be less. If ice segregation should occur in the soil, resulting in a substantial increase in the water content, it is evident that the depth of frozen soil will be reduced because of the heat required to change the temperature and freeze the additional water.

Correlation Between Frost Penetration and Freezing Index. By taking careful and systematic observations, it is believed possible to correlate, with reasonable accuracy, the freezing index with the frost penetration or depth of frozen soil beneath snow-free areas in soils of similar thermal properties. Such a correlation for moist sand and gravel in which ice segregation as a result of frost action does not occur has been started, based upon studies now in progress by the Boston District, U. S. Engineer Department. The results of selected observations are shown in Figure 2. Also plotted in Figure 2 are selected results of observations reported by Fuller (3) in a similar soil.

A straight line has been drawn through the selected observed points and agrees in shape and slope with that indicated by Berggren's solution. This line represents the maximum depth of freezing beneath snow-free areas for various values of the freezing index. As additional data become available, it may be possible to plot several such curves which will represent the maximum depth of freezing for selected groups of soils.

Freezing Index Frequency. The Weather Bureau records at a given location may be studied statistically, in the same manner that flood flows of rivers are studied, and the freezing index corresponding

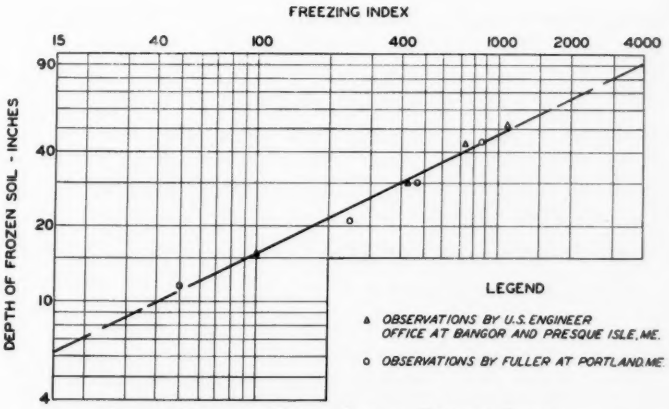


FIG. 2.—DEPTH OF FROZEN SOIL VS. FREEZING INDEX.

to a selected frequency may then be used for determining the depth to which water mains should be covered. Figure 3 is a probability plot of a 65-year record at Portland, Maine, based upon monthly average temperatures.

It is considered reasonable to base the depth of water mains upon conditions to be expected 1% of the time or once in 100 years. From Figure 3, the freezing index corresponding to a frequency of 1% is 1400. The depth of frozen soil for this freezing index is found to be 54 inches from Figure 2. This value is close to the depth of frost of 58 inches observed during the most severe winters at Portland based upon information furnished the writer by Harry U. Fuller, Chief Engineer, Portland Water District. At Portland, all water mains are laid in a trench 5 ft deep regardless of size of pipe except that a minimum cover of 3 ft is required. These requirements are based upon experience which indicates that water in a pipe laid in a trench less than 5 ft deep will freeze during the worst winters at Portland. A 24-in. pipe would have its center at a depth of 48 in., or 6 in. higher than the computed depth of frozen soil. A 12-in. pipe would have its center exactly at the computed depth of frozen soil. Pipes 6 in. in diameter or less would lie below the computed depth of frozen soil. It might appear from these comparisons that

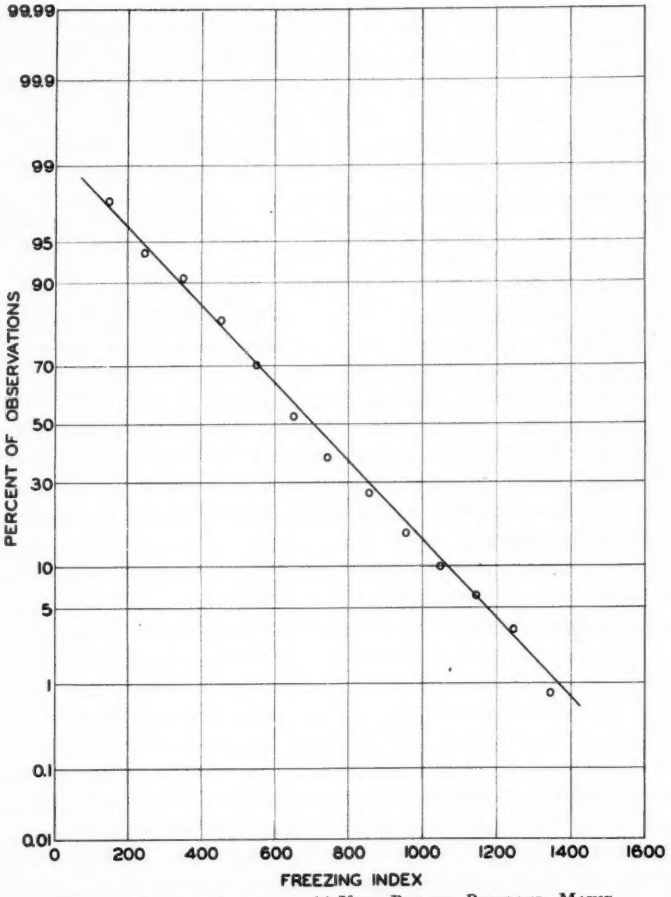


FIG. 3.—FREEZING INDEX FOR 65 YEAR RECORD, PORTLAND, MAINE.

the larger-diameter pipes could freeze in a severe winter. However, when it is considered that the number of miles of large-sized pipe is probably small and that water is probably always in motion through them, it is reasonable to conclude that these larger mains may safely

be placed somewhat closer to the ground surface than the smaller mains. In designing a new installation it would seem reasonable to require that the center of the pipe be placed at a depth of 6 in. below the maximum predicted frost penetration determined as outlined.

The greatest uncertainty in this analysis lies in the accuracy of the correlation between freezing index and depth of freezing. Hence, it is hoped that other investigators will find this method sufficiently worthwhile to contribute to the available data by making careful observations of depth of freezing, soil characteristics, and freezing index.

REFERENCES

1. Highland, Scotland G., Study of Year Round Soil Temperatures, Journal American Water Works Association, **16** (1926), 342 to 354.
2. Casagrande, Arthur, Discussion of Paper by A. C. Benkelman and F. R. Omstead, A New Theory of Frost Heaving, Proceedings Highway Research Board, **2** (1932), 168 to 172.
3. Fuller, Harry V., Studies of Frost Penetration, This Journal, **54** (1940), 275 to 281.
4 Winn, H. F., Lang, F. C., Skelton, R. R., Bennett, E. F., Belcher, D. J., Symposium on Frost Action, Proceedings of the Purdue Conference on Soil Mechanics and Its Applications, 1940, Purdue University.
5. Patten, Harrison E., Heat Transference in Soils, U. S. Department of Agriculture, Bureau of Soils, Bulletin 59 (1909).
6. Berggren, W. P., Prediction of Temperature Distribution in Frozen Soils, Transactions American Geophysical Union, 1943.

PROCEEDINGS

Sixty-fourth Annual Meeting

Boston, Massachusetts

September 11, 1945

The Sixty-fourth Annual Meeting of the New England Water Works Association was held at the Hotel Statler, Boston, Massachusetts, on Tuesday, September 11, 1945.

Morning Session

President Karl R. Kennison in the Chair.

The Annual Reports of the Secretary, Treasurer, Editor, Finance Committee, Committee on Committees, Legislative Committee, Committee on Library, and Committee on Reciprocal Relations with the Institution of Water Engineers (England), were presented, accepted, and ordered placed on file.

The following progress reports of Technical Committees were presented and accepted: Committee on Fire Hydrant Specifications, Committee on Gate Valves, Committee on Laying Cast Iron Pipe, Committee on Meter Specifications, and Committee to Report on Developments in Water Quality Standards.

A final report of the Committees on Post-War Activities and on Water and Sewage Works Development (jointly) was submitted, accepted, and ordered placed on file.

Informal reports were presented by the Committee on Classification of Water Works Employees and Salaries, and the Committee on Threads for Underground Service Lines. All formal reports are printed in this issue of the Journal.

Secretary Gifford presented the following amendments to the constitution. These were adopted on September 10, 1945, by the Executive Committee.

Revised wording of Section 3 of Article II:

"An honorary member shall be a person of eminence in some branch of water works engineering, or a member who has been outstanding in his promotion of the welfare of the Association or of the profession of water supply. There shall be not more than fifteen Honorary Members at any one time."

A new Section 5 to be added to Article VII:

"In the event that a nominee for election to any office shall become incapable through death or disability of assuming the duties of the office, if elected, the procedure for filling such office shall be as follows: The Nominating Committee, upon notification by the Executive Committee, shall on the first day of the next Annual Convention present a nomination, at which time any additional nominations signed by at least ten members may be presented. The office shall be filled by ballot taken on the last day of the Convention, and the nominee receiving the highest number of votes shall be declared elected."

On motion of Warren J. Scott, duly seconded, it was VOTED that the amendments to the constitution be approved.

Secretary GIFFORD announced the following elections to membership in the Association: Kenneth Edgar Shull, Superintendent of Purification, Philadelphia Suburban Water Co., Bryn Mawr, Pa.; Raymond T. Wendell, Division Manager, Water Utilities Service Corporation, Skowhegan, Me.; and George W. Woods, Superintendent, Water Department, Amesbury, Mass.

CLOSING OF POLLS AND APPOINTMENT OF TELLERS

The President declared the polls closed and appointed Roger G. Oakman and William B. Duffy to count the ballots and report their findings to the Association in the afternoon.

Luncheon Session

At this session Alfred A. Doucet of the U. S. Veterans Administration, Boston, Mass., spoke on "Returned Veterans' Problems."

Award of the Dexter Brackett Memorial Medal

Percy A. Shaw. Mr. President, honored guests, and members of the New England Water Works Association, Ladies and Gentlemen:

The Committee on the Award of the Dexter Brackett Memorial Medal for papers published in the New England Water Works Association Journal for the year 1944 consists of Frank E. Hale, Director of Laboratories, Department of Water Supply, Gas and Electricity, New York, N. Y., Henry E. Halpin, Hydraulic Engineer, Inspection Department, Associated Factory Mutual Fire Insurance Companies, Boston, Mass., and the speaker.

Dexter Brackett was chief engineer of the Metropolitan Boston Water Supply for many years and a very influential and valuable member of this Association.

Your committee unanimously selected for the award of the medal a paper by our member Joseph A. McCarthy, in charge of the laboratory of the Lawrence Experiment Station at Lawrence, Mass. Mr. McCarthy has been there since 1910. The Laboratory has been there much longer, and for many years has led the thought on water supply purification not only in New England but throughout the country. The title of Mr. McCarthy's paper, which was first presented in November, 1943, and printed in the March Journal, 1944, was "Bromine and Chlorine Dioxide as Water Disinfectants."

Mr. McCarthy's paper fulfills the requirements for the award of this medal on all counts. It was presented by a member of the Association, it was original in our Journal, it is applicable to general water works problems, covering, as it does, the disinfection of non-filtered as well as filtered water supplies. The subject matter is new, it is important, it is the result of original research, and it was very well presented.

Mr. McCarthy, I have the pleasure of presenting to you the Dexter Brackett Memorial Medal. Congratulations.

Joseph A. McCarthy. Thank you, Mr. Shaw; thank you all. I assure you that I appreciate deeply the honor that is now being paid me. I am particularly pleased today that this award goes to a representative of the Lawrence Experiment Station. I am particularly pleased also that another representative of the Lawrence Experi-

ment Station, Mr. Harry W. Clark, who won this award in 1927, sits beside me today as I receive this award.

I feel quite sure that this honor was not earned by me alone, but that it belongs to all my associates in the Department of Public Health, and especially in the Lawrence Experiment Station, because their cooperation has made research possible and pleasurable, and on this occasion, to me at least, profitable. Again I thank you all.

The President called the attention of the Association to the completion of 25 years of service to the Association by Secretary Gifford. The President also introduced Frank L. Northrup, a member of the Association for more than 52 years.

Afternoon Session

A paper "Community Facilities Program of the Federal Works Agency," was read by L. A. Gillett, Division Engineer, Federal Works Agency, New York, N. Y.

A paper "Cooling Water Benefits from Increased River Flow," was read by M. LeBosquet, Jr., Senior Public Health Engineer, U. S. Public Health Service, Cincinnati, O.

A paper "Pre-Stressed Reinforced Concrete Pipe," was read by F. F. Longley, Lock Joint Pipe Company, East Orange, N. J.

A paper "Water Supply Problems and Practices in Latin America," was read by Homer Hayward, Assistant Chief Engineer, Division of Health and Sanitation, Office of the Coordinator of Inter-American Affairs, Washington, D. C.

A paper "Choice of a Primary Device for Flow Measurement," was read by Leland K. Spink, The Foxboro Company, Foxboro, Mass.

A paper "Cathodic Protection of Pipe Lines," was read by F. M. Ruffing, Magnesium Division, The Dow Chemical Company, New York, N. Y.

REPORT OF TELLERS OF ELECTION

Total Ballots Cast	274
For PRESIDENT, Harold W. Griswold	269
For VICE-PRESIDENT, Donald C. Calderwood	267
For DIRECTOR, Joseph C. Knox	268
For TREASURER, William P. Melley	269

(*Signed*) ROGER G. OAKMAN AND WILLIAM B. DUFFY

The PRESIDENT. I declare that the persons named have been elected to their respective offices.

REMARKS OF THE RETIRING PRESIDENT, KARL R. KENNISON

We have just ended the most momentous war in history. It has literally scarred the face of the earth as no other war has ever done. Our celebrations over the victory have been noticeably sober ones, because this time it is so evident that this is not the end of the struggle.

We hear and read a great deal about better things to come, taxes to be reduced, hours of labor to be shortened, all of which makes little appeal to our intelligence. Real values are expressed only in men's labor and one thing is sure: When men in war time destroy without a trace hundreds of billions of dollars worth of the products of their labor, they make it certain that both they and their children will have long hours of toil ahead of them.

It is true that the war has made tremendous contributions to scientific knowledge, which are going to help men like yourselves, water superintendents and engineers. However, such developments do not mean that we can sit and wait for any miracles to bring Utopia. Instead, they present a distinct challenge: that we bestir ourselves and salvage from the wreckage of war new and more useful materials for our work and better and more efficient techniques. May we thus enhance the value of our service in the field of water supply to our communities.

The President then introduced the incoming President, Harold W. Griswold.

HAROLD W. GRISWOLD. It is a very great honor to be elected President of the New England Water Work Association. I appreciate it very deeply, and I assure you that I shall do my best to serve you well during the ensuing year. I thank you.

(Adjourned).

ANNUAL REPORT OF THE SECRETARY

Mr. President and Gentlemen of the New England Water Works Association: The Secretary submits herewith the following report of the changes of membership during the past fiscal year, and the general condition of the Association.

The present membership is 813, constituted as follows: 11 Honorary Members, 657 Members, 1 Junior Member, 116 Associate Members and 28 Corporate Members.

MEMBERSHIP

				Total
September 1, 1944—Honorary Members, Total		9		
Withdrawals		0	9	
Elected:				
September 18, 1944	1			
November 16, 1944	1		2	11
September 1, 1944—Members, Total		649		
Withdrawals:				
Resigned	8			
Died	13			
Dropped by the Executive Committee	10			
Elected to Honorary Member	2	33	616	
Elected:				
September 18, 1944	14			
October 18, 1944	3			
November 16, 1944	2			
December 21, 1944	3			
January 11, 1945	1			
February 15, 1945	7			
March 15, 1945	6			
April 12, 1945	1			
May 17, 1945	4		41	657

September 1, 1944—Juniors, Total		1		
Withdrawals	0			
Elected	0	0		1
September 1, 1944—Associates, Total		115		
Withdrawals:				
Resigned	3			
Dropped by Executive Committee	0	3	112	
Elected:				
September 18, 1944	1			
December 21, 1944	1			
January 11, 1945	2	4	116	116
September 1, 1945—Corporates, Total		26		
Dropped by Executive Committee	1	1	25	
Elected:				
September 18, 1944	1			
April 12, 1945	1			
May 17, 1945	1		3	28
September 1, 1945—Total Membership				813
September 1, 1944—Total Membership				800
Net Gain				13

ELECTIONS

Honorary Members

September 18, 1944—Arthur D. Weston. (1)
November 16, 1944—David E. Moulton. (1)

Members

September 18, 1944—Maurice L. Brashears, Jr., Patrick B. Bresnahan, John J. Callahan, Walter C. Campbell, Mayo Carrington, John B. Collins, Martin F. Finnegan, Howard G. Marsden, Edward J. Murphy, Clayton E. Osborn, Charles G. Richardson, Howard J. Stewart, Theodore E. Veltfort, and Michael B. Oates (Reinstated). (14)
October 18, 1944—Boyd A. Bennett, Theodore J. Lecours, and William E. Stanley. (3)
November 16, 1944—Harvey B. Kinnison and Harry P. Loftus. (2)
December 21, 1944—Herman G. Dresser, Burnell E. Fresbee, and William A. Healy. (3)

January 11, 1945—Carl E. Chapman. (1)
February 15, 1945—Frank J. Driscoll (reinstated), Raymond F. Goudey, James E. Kenney, Ralph M. Leggette, John F. McDermott, Joseph O'Hanlon, and Nathan T. Veatch. (7)
March 15, 1945—Harvey W. L. Doane, Harry M. Freeburn, Joseph W. Gerniglia, John R. Kaye, Edward V. O'Donnell, and DeVer C. Warner. (6)
April 12, 1945—Oliver W. Tornrose. (1)
May 17, 1945—Otto J. Meotti, Robert W. Moir, Ernest D. Mortenson, and Harold J. Toole. (4)

Associate Members

September 18, 1944—Royer Foundry and Machine Company. (1)
December 21, 1944—Nukem Products Corporation. (1)
January 11, 1945—Edward F. Hughes Company and Northrop & Company, Inc. (2)

Corporate Members

September 18, 1944—Board of Public Works, Gardner, Massachusetts. (1)
April 12, 1945—Board of Water Commissioners, Kingston, Massachusetts. (1)
May 17, 1945—Bellingham Water Board, Bellingham, Massachusetts. (1)

WITHDRAWALS

Members

Resigned: Gordon Campbell, Henry C. Jones, Harry J. Krum, Charles B. Loomis, Ernest A. Merrithew, J. Stanley McClenahan, Francis J. Seery, and David R. Smith. (8)
Died: Clarence M. Blair, George L. Bean, George E. Bolling, Steve C. Burghardt, William F. Covil, George S. Davison, Charles D. Howard, Edward F. Hughes, Edmund C. Knight, Henry V. Macksey, Lyle S. Proffitt, William A. Steinhurst, and John C. Whitney. (13)
Dropped by the Executive Committee: Ralph Adams, Malcolm P. Brown, A. H. Bruhn, Joseph E. Conley, Clifford O. Duval, G. E. Lourie, Roger W. Moran, Frank A. Nicoli, Walter A. Peirce, and Joseph E. Tracy. (10)

Associate Members

Resigned: National Meter Company, Phoenix Meter Corporation, and L. A. Salomon & Bros. (3)

Corporate Members

Dropped by the Executive Committee: New Rochelle Water Company, New Rochelle, New York. (1)

RECEIPTS FOR THE FISCAL YEAR SEPTEMBER 1, 1944 TO SEPTEMBER 1, 1945

Entrance Fees			$ 119.00
Annual Dues:			
Members	$1,882.60		
Corporates	160.00		
Associates	1,000.00	$3,042.60	
Fractional Dues:			
Members	70.50		
Corporates	10.00		
Associates	45.00	125.50	
Past Dues:			
Members	102.00		
Associates	20.00	122.00	
1945-1946 Dues:			
Members	988.00		
Corporates	100.00		
Associates	1,180.00	$2,268.00	
Total Dues			$ 5,558.10
Dividends			376.02
Advertisements			3,485.00
Subscription			536.20
Journals			79.75
Reprints			64.10
Membership Certificates			16.50
Sundries			32.92
Total Receipts			$10.267.59
There is due the Association:			
Dues	$ 297.00		
Entrance Fees	6.00		
Advertisements	3.00		
Subscriptions	20.00		$ 326.00
Total			$10,593.59

Dues of 42 members in our Armed Forces or in enemy occupied countries were remitted.

Respectfully submitted,

(*Signed*) FRANK J. GIFFORD, *Secretary*

ANNUAL REPORT OF THE TREASURER

Boston, September 10, 1945

To Frank J. Gifford, Treasurer
New England Water Works Association,
Boston, Massachusetts

We have examined the statement of assets and funds and the statement of cash receipts and disbursements of the general fund of the New England Water Works Association for the fiscal year ended August 31, 1945. In connection therewith we have reviewed the accounting procedures of the association and have examined accounting records of the association and other supporting evidence, by methods and to the extent we deemed appropriate.

We traced all recorded receipts into the depository bank, verified the general fund bank account and petty cash fund as at August 31, 1945, and examined properly approved vouchers for all disbursements. We also verified by direct communication the investment funds on deposit in savings banks, and on September 6, 1945, we examined the United States War Savings Bonds at the First National Bank of Boston.

In our opinion, the accompanying statement of assets and funds and the note thereon and the related general fund cash statement present fairly the position of the New England Water Works Association at August 31, 1945, and the recorded cash receipts and disbursements for the fiscal year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(*Signed*) SCOVELL, WELLINGTON & COMPANY

STATEMENT OF ASSETS AND FUNDS (EXHIBIT A)
As at August 31, 1945

Cash in Banks, Invested Funds		
Farmers and Mechanics Savings Bank, Framingham, Massachusetts	$1,068.46	
Franklin Savings Bank, Boston, Massachusetts	1,000,00	
Haverhill Savings Bank, Haverhill, Massachusetts	1,000.00	
Home Savings Bank, Boston, Massachusetts	1,000,00	
Mechanics Savings Bank, Reading, Massachusetts	1,000.00	
Pentucket Savings Bank, Haverhill, Massachusetts	1,000.00	
The People's Savings Bank, Worcester, Massachusetts	1,000.00	
Suffolk Savings Bank, Boston, Massachusetts	1,000.00	8,068.46
Securities		
United States War Savings Bonds G 2½s, 1954		10,000.00
Total Invested Cash and Securities		18,068.46
General Fund		
Cash, First National Bank of Boston	6,113.62	
In Office	50.00	
	6,163.62	
Furniture and Fixtures	1,180.00	7,343.62
		$25,412.08
Funds		
Invested Funds		$18,068.46
General Fund		
Balance, August 31, 1944	6,485.34	
Add Excess of Receipts over Disbursements, Exhibit B	858.28	
Balance, August 31, 1945		7,343.62
		$25,412.08

Note: The statement above, prepared on a cash basis includes dues received in advance, $2,268.00, and employees' withholding tax, $36.90. It does not reflect the following:

Accounts Receivable, Dues and Initiation Fees	$ 303.00
Due on Account of Advertising and Subscriptions	23.00
	$ 326.00

No depreciation has been taken on Furniture and Fixtures.

STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS (EXHIBIT B)

General Fund

For the Year ended August 31, 1945

Receipts (exclusive of dues received in advance and employees' withholding tax)			
Initiation Fees		$ 119.00	
Dues, 1944-1945 and Prior Years		3,290.10	
Interest		376.02	
From Publication of Journal			
Advertisements	$3,485.00		
Subscriptions	536.20		
Sale of Journal	79.75		
Sale of Reprints	64.10		
Sale of Halftones, Electros, etc.	24.71	4,189.76	
Miscellaneous			
Membership Certificates	16.50		
Sundry	8.21	24.71	
Total Receipts			7,999.59
Disbursements			
Publication of Journal			
Printing	2,411.46		
Plates	451.23		
Reporting	193.82		
Reprints	65.13		
Stationery and Postage	82.68		
Editor's Salary	500.00		
Sundry	29.87	3,734.19	
Office and General			
Certificates of Membership	93.07		
Secretary's Salary	400.00		

Assistant to Secretary—Salary	1,753.00		
Treasurer's Salary	100.00		
Treasurer's Bond	12.50		
Printing, Postage and Stationery	301.28		
Office Supplies and Expense	170.76		
Office Rent	1,200.00		
Electricity	63.40		
Telephone and Telegraph	214.63		
Auditing	65.00		
Social Security Taxes	126.40		
Office Assistance	240.00		
Sundry	52.55	4,792.59	
Meetings and Committees			
Badges	25.55		
Water Works School	125.00		
Water and Sewage Works Development Committee	18.00		
Post-War Activities Committee	5.00		
Printing, Postage and Stationery	573.82		
Convention Expense	43.72		
Sundry Expense	128.34	919.43	
Total Disbursements			9,446.21
Excess of Disbursements over Receipts (exclusive of dues received in advance and employee's withholding tax)			1,446.62
Dues Received in Advance		2,268.00	
Employees' Withholding Tax		36.90	2,304.90
Excess of Receipts over Disbursements, Exhibit A			858.28
Balance, General Cash, August 31, 1944			5,305.34
Balance, General Cash, August 31, 1945			
Represented by			
Cash in First National Bank of Boston		6,113.62	
Cash in Office		50.00	
			$ 6,163.62

ANNUAL REPORT OF THE EDITOR

To the New England Water Works Association:

The Editor submits herewith the following report for the year ending August 31, 1945.

As has been customary in the past, the tables of financial figures, accompanying the report, are based upon total charges and accounts receivable, rather than actual cash received or disbursed. A detailed statement of the receipts and disbursements on account of the September and December, 1944, and March and June, 1945, issues of the JOURNAL is included in the report of the Treasurer.

TABLE 1.—STATEMENT OF MATERIAL IN SEPTEMBER AND DECEMBER, 1944, AND MARCH AND JUNE, 1945, ISSUES OF THE JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

	Papers	Proceedings	Total Text	Index	Advertisements	Cover and Contents	Insert Plates	Total	Total Cuts
Sept., 1944	75	15	90	0	40	4	0	134	3
Dec., 1944	74	38	112	10	40	4	0	166	12
Mar., 1945	101	19	120	0	42	4	1	167	10
June, 1945	111	5	116	0	42	4	1	163	30
Total	361	77	438	10	164	16	2	630	55

Table 2 gives a comparison of the JOURNAL for the past year with preceding years.

Size. The four issues contained 630 pages, of which 438 were text.

Cost. The gross cost of the JOURNAL was $3,734.19, equivalent to $4.63 per member; the net profit was $455.57, equivalent to $0.72 per member.

Reprints. Reprints of papers have been furnished to authors at cost.

TABLE 2.—COMPARISON OF JOURNALS OF THE NEW ENGLAND WATER WORKS ASSOCIATION. FOUR ISSUES FOR FISCAL YEAR ENDING AUGUST 31.

	1936	1937	1938	1939	1940	1941*	1942‡	1943**	1944	1945
Average edition (copies printed)	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,175	1,200	1,200
Average membership	770	772	785	795	796	800	803	798	799	806
Circulation at end of year	903	920	943	946	967	943	982	969	1,015	1,032
Pages of text	477	423	510	488	565	540	575	442	442	438
Pages of text per 1,000 members	619	561	650	614	710	675	716	554	553	543
Total pages, all kinds	642	627	699	670	762	733	757	616	621	630
Total pages, per 1,000 members	834	812	890	843	957	918	943	772	777	782
GROSS COST:										
Total	$5,880.68	$5,040.86	$4,658.05	$4,119.30	$3,846.46	$4,415.00	$4.053.47	$4,234.68	$3,406.48	$3,734.19
Per copy	1.35	1.23	1.06	0.94	0.87	1.00	0.93	0.90	0.71	0.78
Per page	9.16	8.04	6.66	6.15	5.05	5.66	5.36	6.87	5.49	5.83
Per member	7.64	6.53	5.93	5.18	4.33	5.52	5.05	5.31	4.26	4.63
Per member per 1,000 pages	11.89	10.41	8.49	7.13	6.34	7.53	6.67	8.61	6.87	7.35
Per member per 1,000 pages of text	16.01	15.01	11.63	10.61	8.55	10.21	8.78	12.01	9.66	10.57
NET COST:										
Total	$1,499.58	$489.13	$539.21	$306.77†	$618.37†	$276.54	$534.72	$609.81	$407.21†	$455.57†
Per copy	0.34	0.11	0.12	0.07†	0.14†	0.06	0.12	0.13	0.08†	0.09†
Per page	2.34	0.78	0.77	0.46†	0.81†	0.38	0.71	0.99	0.66†	0.72†
Per member	1.95	0.63	0.69	0.39†	0.78†	0.35	0.67	0.76	0.51†	0.57†
Per member per 1,000 pages	3.03	1.01	0.98	0.58†	1.02†	0.47	0.88	1.24	0.82†	0.90†
Per member per 1,000 pages of text	4.08	1.46	1.35	0.80†	1.37†	0.64	1.16	1.73	0.92†	1.29†

*Including comprehensive index, 1882 to 1939, and 102 pages of standard specifications.
‡Including 45 pages of standard specifications.
**Including 28 pages of standard specifications.
†Profit.

Circulation. The present circulation of the JOURNAL is:

Members, all grades	813
Subscribers	134
Exchanges	24
Advertisers	61
Total	1,032

JOURNALS have been sent to all subscribers and to advertisers.

Respectfully submitted,

(*Signed*) GORDON M. FAIR, *Editor*

ANNUAL REPORT OF THE FINANCE COMMITTEE

August 31, 1945

To the Executive Committee of the New England Water Works Association

GENTLEMEN:

Your Finance Committee presents herewith its report on Finances for the year 1944-1945 and its recommended budget for the year 1945-1946.

The Committee has examined figures obtained from records which were audited by a certified public accountant.

The budget of revenue for the past year was conservatively made up, as the actual receipts exceeded the estimate in total by $760.93. Most of this is shown in the tabulation as receipts from advertising in the JOURNAL.

Last year's estimated expenditures were very close to the actual figures in total. The increase in office expenses was offset by savings made in printing the JOURNAL and incurred by meetings and committees.

During the year the following changes have occurred in the membership roster:

	Resigned	Deaths	Dropped	New	Gain
Members	8	13	10	41	10
Corporate Members	0	0	1	3	2
Associate Members	3	0	0	4	1
Totals	11	13	11	48	13

REVENUE FOR 1944-1945

	Budget	Actual	Difference
Initiation Fees	$ 150.00	$ 119.00	$ 31.00 Minus
Dues	5,400.00	5,558.10*	158.10 Plus *
Interest and Dividends	325.00	376.02	51.02 Plus
Journal	3,600.00	4,189.76	589.76 Plus
Miscellaneous	75.00	68.05	6.95 Minus
	$9,550.00	$10,310.93	$760.93

*This figure includes $2,286.00 dues received in advance August 1945.

EXPENDITURES FOR 1944-1945

	Budget	Actual	Difference
Office	$4,200.00	$4,757.09	$557.09 Plus
Journal	4,000.00	3,746.79	253.21 Minus
Meetings and Committees	1,300.00	965.27	334.73 Minus
Miscellaneous	50.00	0.00	50.00 Minus
	$9,550.00	$9,469.15	$ 80.85 Minus

Excess of Receipts over Expenditures $841.78

BUDGET FOR 1945-1946, REVENUE

Initiation Fees	$ 150.00
Dues	5,600.00
Interest and Dividends	375.00
Journal	4,000.00
Miscellaneous	50.00
Total	$10,175.00

BUDGET FOR 1945-1946, EXPENDITURES

Office	$4,600.00
Journal	3,800.00
Meetings and Committees	1,000.00
Miscellaneous	50.00
Total	$9,450.00

The Committee in collecting figures for the 1945-1946 budget, gave consideration to the current reconversion from war to peace economy and was guided by the actual figures of the year just ended.

The report of audit is part of the report of the Treasurer.

Respectfully submitted,

(*Signed*) MARK F. CROKER, *Chairman*
WILLIAM P. MELLEY
ALLAN F. MCALARY

ANNUAL REPORT OF COMMITTEE ON COMMITTEES

September 10, 1945

To the New England Water Works Association: This committee, appointed by the Executive Committee of the Association to promote coordination of committee activities in the Association and to promote the establishment of new technical committees where this seems advisable, submits a brief report. Committee activities have been curtailed under war conditions. Our Committee has followed its usual practice of communicating with the various committee chairmen to ascertain their ideas as to continuance of committees and their plans with regard to reports. We have also checked up during the year with other associations regarding joint committees. The Program Committee has been advised as to those committees desiring to submit reports at the annual meeting.

Few changes were made during the year as to designation of committees. The Committee on Water Works Education was discontinued inasmuch as this work is being handled directly by the officers of the Association, and the Committee on Wartime Water Works Information was discontinued because of a duplication with work of other committees. A new and important "Committee to Report on Developments in Water Quality Standards" was appointed in view of the discussions that have arisen concerning the promulgation of new standards of water quality by the U. S. Public Health Service, for supplies used on interstate carriers.

The following committees will either submit progress reports or in the opinion of this committee should be continued:

Committee on Committees.

Committee on Specifications for Cast Iron Pipe and Special Castings. (Sectional Committee under A.S.A.)

Committee on Cathodic Protection of Steel Tanks and Standpipes.

Committee on Classification of Water Works Employees and Salaries.

Sectional Committee on Code for Pressure Piping. (Joint Committee with A.S.M.E.)
Committee on Coefficients for Friction in Pipe Lines.
Committee to Report on Developments in Our Knowledge of Corrosion and Its Mitigation.
Committee to Report on Developments in Water Quality Standards.
Committee on Fire Hydrant Specifications. (Joint Committee with A.W.W.A.)
Committee on Gate Valves. (Joint Committee with A.W.W.A.)
Committee to Investigate Grounding. (Cooperating with the American Research Committee on Grounding)
Committee on Laying Cast Iron Pipe. (Joint Committee with A.W.W.A.)
Committee on Legislation.
Committee on Library.
Committee on Membership.
Committee on Meter Specifications. (Joint Committee with A.W.W.A.)
Committee on Post-War Activities. (Joint Committee with N.E.S.W.A.)
Committee on Finance.
Committee on Rainfall and Yield of Drainage Areas.
Committee on Reciprocal Relations with the Institution of Water Engineers (England)
Committee on Reinforced Concrete Pressure Pipe. (Joint Committee with A.W.W.A.)
Committee on Sluice Gates. (Cooperating with Committee of A.W.W.A.)
Committee on Standardization of Pipe Flanges and Fittings. (Sectional Committee under A.S.A.)
Committee on Specifications on Steel Pipe. (Joint Committee with A.W.W.A.)
Committee on Steel Standpipes and Elevated Tanks. (Joint Committee with A.W.W.A.)
Committee on Survey of Ground Water Supplies in New England.

Committee on Survival and Retirement Experience with Water Works Facilities. (Joint Committee with A.W.W.A.)
Committee on Technical Program.
Committee on Threads for Underground Service Lines. (Joint Committee with A.W.W.A.)
Committee on Valve Box Frames and Covers. (Joint Committee with A.W.W.A.)
Committee on Water and Sewage Works Development. (Joint Committee with A.W.W.A.)
Committee on Water Quality Tolerances for Industrial Uses.

Discontinuance of Committees. It would appear that the Committee on Wartime Activities, a joint committee with the A.W.W.A., should be discontinued, and this is recommended.

New Committees: The Committee has submitted no recommendations relative to the appointment of new committees for the coming year although, after the country is adjusted to a full peace-time basis, it may be possible to consider additional committee activities.

Postwar Developments: The end of the war brings with it possibilities of extensive water supply improvements. There is a great back-log of needed construction in this field. The Association now has a "Committee on Post-War Activities".

Conclusions and Recommendations: It is recommended that the standing committees listed be re-appointed. No recommendations for additional committee assignments are made at this time. With the adjustment of the country to a full peace-time basis, it is hoped that the Association can soon develop a more extended program of public education in the water supply field. This could be promoted through committee activities.

Respectfully submitted,

(*Signed*) WARREN J. SCOTT, *Chairman*
THOMAS R. CAMP
HARRY U. FULLER
ARTHUR C. KING
ARTHUR L. SHAW

ANNUAL REPORT OF THE LEGISLATIVE COMMITTEE

To the New England Water Works Association: Your Legislative Committee has again this year been on the alert, each member in his own state, for any legislation affecting water works management and operation. This report is, therefore, made up of sections, one for each state.

Massachusetts. In Massachusetts, few bills were presented which would seriously affect water works procedure, but attention should be called to some.

Chapter 606 provides for emergency water supplies to be taken by eminent domain after approval by the Department of Public Health.

Chapter 615 authorizes the Department of Public Health to regulate pollution of both inland and tidal waters.

Chapter 367 provides that payments in lieu of taxes on property acquired in another municipality after January 1, 1945, shall be based on the average assessed evaluation for three years preceding the acquisition.

Rhode Island. In Rhode Island water works interest centered in the passage of legislation establishing the Kent County Authority. This act creates an agency by means of which two cities and five towns may purchase three privately-owned water systems now serving them or may construct new systems of supply. The act is a permissive one authorizing the towns and cities to take such steps as they deem necessary to protect their interests, acting as one or as several water authorities.

Enactment of this legislation was prompted by the disclosure that the privately-owned systems were to be placed on the market with the resulting danger of absentee ownership which might work to the disadvantage of the municipalities affected.

A similar act was also passed at the request of the towns in Bristol County.

Connecticut. In Connecticut, several bills concerning water systems were presented but none of adverse effect were passed.

New Hampshire and Maine. In New Hampshire and Maine, there was no action of interest.

Vermont. In Vermont, an act was passed to enable the town of Brattleboro to issue bonds for the installation of a filter plant for its water system.

Another act, No. 49, is an enabling act of general application, entitled "An Act to Authorize a Municipal Corporation to Organize and Conduct a Water Department and to Issue Water Bonds Therefor."

This act authorizes and establishes the procedure for the acquisition, construction, financing, management, and operation, including rate making, of a water system and seems to your Committee to be comprehensive enough to justify its inclusion in this report complete, for reference.

NUMBER 49 OF THE ACTS OF THE LEGISLATURE OF 1945

AN ACT TO AUTHORIZE A MUNICIPAL CORPORATION TO ORGANIZE AND CONDUCT A WATER DEPARTMENT AND TO ISSUE WATER BONDS THEREFOR

It is hereby enacted by the General Assembly of the State of Vermont:

Section 1. A municipal corporation is hereby authorized and empowered to construct, maintain, and repair an artesian well, reservoir or reservoirs, pumps, engines and apparatus, take, purchase and acquire, in the manner hereinafter mentioned, any artesian wells, ponds, springs, streams, water courses, real estate, water rights, flowage rights, and easements necessary for its purposes within the limits hereinafter described, together with such land surroundings and adjacent to the same as may be reasonably necessary for protecting and preserving the purity of the water in such artesian wells, ponds, springs and streams, and may enclose such artesian wells, ponds, springs and streams by suitable fences for the purpose of such protection; and to enter in and upon any land or reservoirs, lay pipes and aqueducts, and connect the same with the main aqueduct as may be necessary to convey the water taken as aforesaid to the reservoirs of such municipal corporation and distribute the same through such municipal corporation for the purpose of supplying the inhabitants thereof, with water for fire, domestic and other purposes; but such municipal corporation shall not take otherwise than by purchase, water or a spring of water which the owner or leasee or other person having a vested right or interest in said water or the use thereof, may reasonably require for domestic use or the watering of animals on the premises where such water may be in use.

Sec. 2. Such municipal corporation for the purposes enumerated in the foregoing section may enter upon and use any land and enclosures over or through which it may be necessary for an aqueduct or pipes to pass and may thereon dig,

place, lay and construct such pipes, aqueducts, reservoirs, appurtenances and connections as may be necessary for the complete construction and repairing of the same from time to time, may open the ground in any streets, lanes, avenues, highways and public grounds for the purpose of laying down, and repairing such pipes, aqueducts, reservoirs, and appurtenances, as may be necessary for conducting the water and the purposes aforesaid; provided that such streets, lanes, avenues, highways and public grounds shall not be injured, but shall be left in as good condition as before the laying of said pipes, aqueducts, reservoirs, and appurtenances.

Sec. 3. Such municipal corporation may agree with the owner or owners of any property, franchise, easement or right which may be required by such municipal corporation for the purposes of this act, as to the compensation to be paid therefor. In case of failure to agree as to such compensation, or in case such owner is an infant, insane, absent from the state, unknown, or the owner of a contingent or uncertain interest; a superior judge may on the application of either party cause such notice to be given of such application as he may prescribe, and after proof thereof, may appoint three disinterested persons to examine such property to be taken, or damaged by such municipal corporation, such commissioners after being duly sworn, shall, upon due notice to all parties in interest, view the premises, hear the parties in respect to such property, and shall assess and award to such owners and persons so interested just damages for any injury sustained as aforesaid and make report in writing to such judge. The judge may thereupon accept such report, unless just cause is shown to the contrary, and order such municipal corporation to pay the same in such time and manner as such judge may prescribe, in full compensation for the property taken, or the injury done by such municipal corporation, or said judge may reject or recommit said report if the ends of justice so require. On compliance with such order such municipal corporation may proceed with the construction of its work without liability for further claim for damages. Such judge may award costs in such proceeding in his discretion.

Sec. 4. Such municipal corporation shall within sixty days after the taking of any property, franchise, easement or right under the provisions of this act file in the office of the clerk of the municipal corporation where the same is situated, a description thereof.

Sec. 5. Such municipal corporation may contract with any town, city or village, any corporation and individuals to supply water to such municipal corporation for the protection of property and for domestic and other purposes.

Sec. 6. The owner or occupant of any tenement, house or building, who takes the water of such municipal corporation shall be liable for the rent or price of the same, and the officers and agents of such municipal corporation intrusted with the care and superintendence of the water may at all reasonable times enter all premises so supplied to examine the pipes and fixtures and prevent any unnecessary waste. If any person or persons without the consent of such municipal corporation shall use any water, an action of tort under this statute may

be maintained against such person, by such municipal corporation for the recovery of damages therefor. The charges, rates or rents for water shall be a lien upon the real estate furnished with the municipal corporation water in the same manner and to the same effect as taxes are a lien on real estate under sections 780 and 825 of the Public Laws.

Sec. 7. If any person or persons divert the water, or part thereof, of any of the artesian wells, ponds, springs, streams, aqueducts, water courses or reservoirs, which shall be taken, used or constructed by such municipal corporation, or shall corrupt the same, or make it impure, or commit any nuisance therein, or shall bathe therein, or within the limits, that may be taken or prescribed by such municipal corporation pursuant to the provisions of this act, or injure or destroy any artesian well, dam, embankment, aqueduct, pipe, reservoir, conduit, hydrant, structure, pump, machinery, or other property held, owned or used by such municipal corporation under the provisions of this act, shall be liable to such municipal corporation in treble damages therefor, to be recovered in an action of tort founded on this statute, and any such person on conviction of either such act, shall be fined not exceeding one hundred dollars or imprisoned in the house of correction not exceeding six months.

Sec. 8. For the purpose of successfully organizing, establishing and operating its water works, and making such improvements as may be necessary, such municipal corporation is authorized and empowered to purchase, take and hold real and personal estate; levy and collect such taxes upon the polls and ratable estate of the municipal corporation as is necessary for the payment of municipal corporation water department expenses, and indebtedness; issue its negotiable bonds in such sums and payable at such times and places as may be deemed advisable, for the purpose aforesaid only; and borrow such money from time to time, as may be necessary to enable the water department to carry on the work of adequately supplying the municipal corporation with water.

Sec. 9. All taxes laid, all loans authorized and all bonds negotiated, shall be laid, authorized and negotiated by virtue of a two-thirds vote of the duly qualified voters of such municipal corporation attending a meeting duly warned and holden for that purpose. At least seventy-five per cent of the water bonds so issued shall not be considered as a part of the indebtedness of such municipal corporation; as limited by the provisions of section 3609 of the Public Laws, provided, however, such bonds are secured by the physical assets of its municipal water department.

Sec. 10. Such municipal corporation may establish rates by meter service or annual rents to be charged and paid at such time, and in such manner as such municipal corporation shall determine for the supply of water to the inhabitants of such municipal corporation and others, and may from time to time alter, modify, increase or diminish such rates, and extend them to any description of property or use as such municipal corporation may deem proper. Such rates or rents may be ordered to be paid in advance and all necessary orders and provision may be made and enforced by such municipal corporation, relating to the

supply or stoppage of water, as it may deem necessary to insure such advance payments.

Sec. 11. The selection or trustees of such municipal corporation shall constitute a board of water commissioners.

Sec. 12. Such water commissioners shall have the supervision of such municipal water department and shall make and establish all needful water rates, rules and regulations for its control and operation. Such commissioners may appoint or remove a superintendent at their pleasure. The rents and receipts for the use of such municipal water shall only be used and applied to pay the interest upon the water bonds of such municipal corporation; the expense of repairs and management of the water department; and in payment of the municipal water department bonds. The money received from the operation of such municipal water department shall not be used for any other purposes until all such bonds have been paid.

Sec. 13. Every bond issued by such municipal corporation for water purposes, in pursuance of this act, shall be signed by the municipal corporation clerk and by the municipal corporation treasurer of such municipal corporation and shall have the certificate of the clerk of such municipal corporation that said bond is one of a series authorized by such municipal corporation, and its records shall be so kept as to show the issue of the bonds, the amounts and dates of the same, when due, and the time of their payment.

Sec. 14. Such municipal corporation shall have the power to make, establish, alter, amend or repeal ordinances, regulations and by-laws relating to the matters contained in this act and not inconsistent with law, and to impose penalties for the breach thereof, and enforce the same.

Sec. 15. Any action taken by such municipal corporation under the provisions of this act or relating to the matters therein set forth, shall be by vote of the majority of the legal voters of such municipal corporation, at a meeting duly warned and holden, unless otherwise provided.

Sec. 16. This act shall take effect from its passage.

Approved March 9, 1945.

Respectfully submitted,

(*Signed*) ARTHUR C. KING, *Chairman*
SIDNEY S. ANTHONY
THEODORE L. BRISTOL
MADISON H. GOFF
PHILIP J. HOLTON, JR.
PERCY R. SANDERS
EDWARD L. TRACY

ANNUAL REPORT OF THE COMMITTEE ON LIBRARY

September 11, 1945

To the New England Water Works Association: It is again the duty of your Committee on Library to call your attention to the limited use of the library by the members of the Association.

The library is not extensive but it does contain standard works on water supply and files of bound Water Works Journals. In addition many current periodicals are available, a list of which is appended.

The Committee urges the membership to make greater use of the library and of the Association headquarters.

Respectfully submitted,

(*Signed*) E. SHERMAN CHASE, *Chairman*
FRANCIS A. KINGSBURY

APPENDIX

PUBLICATIONS RECEIVED BY THE NEW ENGLAND WATER WORKS ASSOCIATION

American City Magazine
Civil Engineering (Am. Soc. Civil Engineers)
Civil Engineering, London, England
Journal of the American Water Works Association
Journal of the Institution of Water Engineers (England)
Journal of the Boston Society of Civil Engineers
Journal of the Franklin Institute
Journal of Maine Water Utilities Association
Journal of the New Hampshire Water Works Association
Mechanical Engineering Magazine
Military Engineering Magazine
New England Construction Magazine
Proceedings of the American Society of Civil Engineers
Public Health Abstracts
Water and Water Engineering—England
Water Works Engineering Magazine
Water Works & Sewerage Magazine

ANNUAL REPORT OF THE COMMITTEE ON RECIPROCAL RELATIONS WITH THE INSTITUTION OF WATER ENGINEERS

September 11, 1945

To the New England Water Works Association: The end of World War II is so recent that your Committee on Reciprocal Relations with the Institution of Water Engineers of England can report limited activity only.

We are pleased to announce, however, that your President, Mr. Karl R. Kennison, has prepared an excellent exchange paper, which has been sent to the Institution. This paper, entitled "Water Supply Developments in Boston, Massachusetts, and Recent Additions to the Works," will be presented by Mr. H. J. F. Gourley, Honorary Member and Past President of the Institution, at its Winter Meeting next December.

We trust that within a year or two a representative of the Institution will prepare a return paper and possibly attend one of our meetings in person. With the advent of peace and its many international problems, it is the earnest hope of your Committee that the friendly relations between our two Associations will be continued and fostered.

Respectfully submitted,

(*Signed*) E. Sherman Chase, *Chairman*
Leland G. Carlton
Percy A. Shaw

FINAL REPORT OF THE COMMITTEES ON POSTWAR ACTIVITIES AND ON WATER AND SEWAGE WORKS DEVELOPMENT

September 11, 1945

To the New England Water Works Association: The end of the war eliminates the necessity for continuing the committees on postwar planning. A brief review of their activities appears desirable as a matter of record.

The Committee on Postwar Activities was authorized three years ago by this Association and a year later was made a joint committee with a similar committee of the New England Sewage Works Association. The work of the Committee has consisted largely of promoting interest in postwar planning among the members of the two associations. Particularly active in the missionary work have been the sanitary engineers of the health departments of the six New England states who have also been members of the Committee. Your Committee believes that the membership of this Association has been stimulated to look ahead to the postwar period and to prepare as adequately as possible to meet the needs thereof.

The Committee has not attempted to gather statistics as to the dollar value of planned postwar work but it is common knowledge that most water works superintendents have been laying plans for substantial improvements to their system and for catching up with deferred maintenance. It is the opinion of your Committee that these plans should be put into execution just as soon as labor and materials are available.

Particular effort should be made to reemploy ex-servicemen. The average water works superintendent can perhaps do but little to provide postwar employment but he should not fail to do what he can. In the aggregate water works men can help much in providing jobs and it is up to every member of this Association to do his part.

The Committee on Water and Sewage Works Development is a national committee, established in July 1943, sponsored by this

Association, the American Water Works Association, the Federation of Sewage Works Associations, and the Water and Sewage Works Manufacturers Association. Roger Esty and E. Sherman Chase are the members representing the New England Water Works Association. The work of the Committee has been nationwide and the untiring efforts of its able Field Director, E. L. Filby of Kansas City, in spreading the gospel of "Blue Print Now" deserves special mention. The New England Water Works Association contributed about $600 to help finance the Committee, and the remaining costs were borne by the other associations.

In conclusion the Committees wish to urge every member of the Association to show by his deeds that the exhortations of the Committees have not been in vain.

Respectfully submitted,

(*Signed*) E. Sherman Chase, *Chairman*
Roger Esty
Theodore Cate
Richard Ellis
Harold W. Griswold
J. Elliott Hale
G. E. Hawkins
Philip J. Holton, Jr.
Howard H. Potter
Fred J. Reny
Warren J. Scott
Walter J. Shea
Edward L. Tracy
Arthur D. Weston

PROGRESS REPORT OF THE COMMITTEE ON DEVELOPMENTS IN WATER QUALITY STANDARDS

September 11, 1945

To the Members of the New England Water Works Association:
The standards for drinking (and culinary) water provided for common carriers in interstate traffic, as adopted by the U. S. Public Health Service on September 25, 1942, met with certain objections by operating water works officials. Accordingly, under date of September 1, 1944, the U. S. Public Health Service issued a statement of policy to be followed by that Service in interpretation of those standards; but inasmuch as these standards are often applied to water used other than on common carriers, objections continued and requests were made for the preparation of separate "professional" standards which could be adopted by the water works associations for all public water supplies in the United States whether or not supplying common carriers for interstate traffic. It seems obvious to many that the existence of two sets of standards would create serious confusion, and the Public Health Service was requested to make certain modifications in its standards so as to make them more adaptable to all drinking waters.

Committees of the New England Water Works Association, the American Water Works Association, representatives of the Conference of State Sanitary Engineers, and members of the Advisory Committee on Revision of the Drinking Water Standards for the U. S. Public Health Service suggested revisions. These suggestions for revision have been considered by the U. S. Public Health Service with the result that a new set of standards has been drafted by the Service and a copy of the proposed new standards with the essential changes underlined has been made available to your Committee.

The proposed revised standards, aside from the changes necessary in wording to make them applicable to all public water supplies in the United States, make definite changes in the following paragraphs:

1.4 There has been a slight change in this paragraph to include anything as a "sanitary defect" which might prevent satisfactory

purification of the water supply or cause it to be contaminated from extraneous sources.

1.10 This paragraph has been changed to indicate that the certifying authority shall be applicable only in those cases involving common carriers and that the reporting agency shall be known to be the official state health agency.

2.2 The principal change in this paragraph is to permit consideration by the U. S. Public Health Service of evidence of regulation of sanitary defects and that they will be removed at a rate satisfactory to the reporting agency and the certifying authority, and for continuing programs for detecting health hazards and sanitary defects within the water distribution system.

2.21 This is an additional paragraph defining the responsibility for conditions in the water supply system, the water purveyor being made responsible only to the point of connection to the customers' service piping. Under this change, responsibility of the owner of the premises supplied and the municipal, county or other authority having legal jurisdiction from the point of connection at the customers' service piping to the free flowing outlet of the ultimate consumer is shown.

3.1 This paragraph has been changed to provide for joint regulation by the reporting agency and the certifying authority of the frequency of bacterial sampling and the location of sampling points. It removes the arbitrary nature of the 1942 standards in this particular. It also excludes the daily check samples from being used for prohibiting the supply if immediate action is taken to locate and remove the cause and if subsequent samples are satisfactory.

4.1 This paragraph is modified as to the requirements relative to turbidity, color, and freedom from taste or odor so as to be mandatory only in connection with filtered water supplies but provides that requirements for either filtered or unfiltered waters should be based on reasonable judgment and discretion.

4.21 This paragraph has been changed to increase the allowable fluoride content from 1.0 part per million to 1.5 parts per million.

It had been hoped by your Committee that the proposed revised standards might be reproduced for early consideration by the

members of this Association, but your Committee has been advised that additional changes may be made and that final revision will not be completed until some time in October. Your Committee believes that the changes thus far made will satisfy most of the objections raised by operating water works officials to the standards as adopted in 1942, and that when the new revision has been made official the new standards will be useful both to public officials concerned with these matters and to the operating managers of all water utilities. In this connection, recommendations have been made to the U. S. Public Health Service by representatives of your Committee and others that the standards be published as a separate document and that the Manual of Recommended Water Sanitation Practice which accompanied the 1942 standards be further revised and published independently.

Your Committee has carefully considered the proposed revised standards and has approved them. If and when further revisions have been made, your Committee will advise the Association and comment thereon.

Respectfully submitted,

(*signed*) ARTHUR D. WESTON, *Chairman*
ALMON L. FALES
MELVILLE C. WHIPPLE

PROGRESS REPORT OF THE COMMITTEE ON FIRE HYDRANT SPECIFICATIONS

September 11, 1945

To the New England Water Works Association: At the annual convention last year the members of the Association reappointed the present hydrant specification committee to serve for another year and work in conjunction with the A.W.W.A. hydrant specification committee on a review of the present hydrant specifications.

The chairman of this Committee is also chairman of the A.W.W.A. committee, and he has kept the members of this Committee informed of proposed changes.

As the A.W.W.A. committee is not ready to submit a revision of the present hydrant specifications at the present time, we suggest that this Committee be reappointed for another year.

Respectfully submitted,

(*signed*) ROGER W. ESTY, *Chairman*

PROGRESS REPORT OF THE COMMITTEE ON GATE VALVES

September 11, 1945

To the New England Water Works Association: The Committee on Gate Valves submits the following Progress Report.

This Committee is a joint one with the American Water Works Association Committee 7F-3 headed by Fred M. Randlett, Vice President and General Manager, Robert W. Hunt Company, Chicago, which is charged with rewriting the present Standard A.W.W.A. Specifications for Gate Valves which also have been accepted by the N.E.W.W.A. as its standard.

As a start towards revision of these present specifications questionnaires were sent out by A.W.W.A. Committee 7F-3 during the past year to 223 water works well distributed over the entire United States, asking the following questions:

1. What are the weak points in the distribution valves in your system?
2. What type of valve repairs are most often needed?
3. Do the present A.W.W.A. Specifications cover your desire?
4. Have you any suggestions you would like to see made as additions to the present Specifications?
5. Will you suggest corrections which you would like to have made?
6. Are the present A.W.W.A. Specifications specific enough to satisfy conditions in your system?

Replies were received from 82 utilities and the information from these is in process of being tabulated. While no conclusion can be reached until the accumulated data can be classified and studied, a preview indicates concern over stem strength, stuffing box design, and protection against internal corrosion.

Mr. Vance C. Lischer, of Horner & Shifrin, Consulting Engineers of St. Louis, has prepared from the Industrial Arts Index an excellent resumé of water works literature since 1913 on the subject of gate

valves, which will be available to the Joint Committee shortly for use as a further aid in the study of gate valves specifications revision.

Respectfully submitted,

(*signed*) H. W. GRISWOLD, *Chairman*
LELAND G. CARLTON
WALTON H. SEARS

PROGRESS REPORT OF THE COMMITTEE ON LAYING CAST-IRON PIPE

September 11, 1945

To the New England Water Works Association: Your Committee, appointed to cooperate with the American Water Works Association in revision of its Specifications for Laying Cast-Iron Pipe, submits the following progress report:

The specifications have been reviewed and a number of revisions have been proposed. The suggested revisions have been submitted to the A.W.W.A. Committee for consideration.

Your Committee will continue to cooperate with the American Water Works Association and will report further at an appropriate time.

Respectfully submitted,

(*signed*) W. S. MARINER, *Chairman*

PROGRESS REPORT OF THE COMMITTEE ON METER SPECIFICATIONS

September 11, 1945

To the New England Water Works Association: At the time of the 1942 September Convention, this Committee presented the final draft of the specifications covering Displacement Type Cold Water Meters. These specifications were subsequently adopted as standard by the Association on May 18, 1943. At that time, work had already started on the development of new specifications for Current and Compound Meters. Due to the extenuating circumstances under which most of us were forced to work during the war period, progress to date on these latter specifications has been slow.

The writer, however, feels that Mr. S. F. Newkirk, Jr., Past President of the American Water Works Association, and Chairman of the Meter Committee for that organization, should be commended for the continued activity of the Committee, the accomplishments of which are largely due to his personal effort.

Three independent drafts of specifications for meters of the Current and Compound Types have been prepared and presented to the Committees of both interested Water Works Associations. The third and final draft of these specifications has been approved by the majority of the A.W.W.A. Committee members and has been presented to the Water Works Practice Committee and to the Board of Directors of that Association for approval and publication as Tentative Standard Specifications.

The proposed Specifications followed the form of those prepared for Displacement Meters. All the features common between Current and Compound Meters and Displacement Type Meters have been incorporated in the new specifications. The principal point of discussion between the two Committees has been the limit of accuracy to specify. The Specifications as now written require that the registration on the Meter Dials shall indicate the quantity recorded to be not less than 97% nor more than 103% of the water actually passing

through the meter while it is being tested at any rate of flow within the limits specified under "Normal Test Flow Limits." It was the hope of the N.E.W.W.A. Committee to narrow this limit of accuracy to 2% plus or minus, which limits are now specified by some Public Utility Commissions.

Objections, however, have been raised which apparently led the A.W.W.A. Committee to recommend adoption of the wider limits for meters of this type. While in the writer's opinion this is regrettable, it is recognized that, for the sake of uniformity, the adoption of a "Joint Specification" by both Water Works Associations is of material advantage to the water works profession and to the manufacturers. In view of the fact that this is now the only point of difference between the two Committees, it appears in order to go along with the A.W.W.A. Committee in this respect.

The N.E.W.W.A. Committee therefore expects, in the near future, to present for your consideration and approval as a standard of the Association, Specifications covering Current and Compound Type Meters.

In addition to the foregoing, a first draft of the new Specification for Fire Service Meters has been prepared jointly by the A.W.W.A. and N.E.W.W.A. Committees. Further work on these specifications is now in progress.

Respectfully submitted,

(*signed*) RICHARD H. ELLIS, *Chairman*

PROGRESS REPORT OF THE COMMITTEE ON CLASSIFICATIONS OF WATER WORKS EMPLOYEES AND THEIR SALARIES

September 11, 1945

To the Members of the New England Water Works Association:
Your Committee on Classifications of Water Works Employees and Their Salaries offers an interim report on its assignment.

The scope of the work by this Committee embraces recommendations for classifications, salaries, sick-time policies, and vacation leaves for private and public water works in the six New England States.

In order to set up a satisfactory scale of wage rates, no less than twenty-five to thirty wage-zone areas must be treated separately so that living differentials, peculiar to each area, may be properly and scientifically considered.

To accomplish this purpose it was necessary to send out over two hundred questionnaires so that sufficient working data would be available for the Committee.

Replies to these questionnaires have been disappointingly slow and many were not answered, thus handicapping the work of the Committee. However, your Committee feels that this lack of information from some of the key wage-zone areas may be offset by interpolating wage indices which have been tabulated by the War Manpower Commission.

The first meeting of the Committee was held on June 20 of this year in the Association rooms and the scope of the committee work was decided upon. The Committee noted during its deliberations that there is a definite need for standardizing wages for each classification, also that there are no uniform vacation or sick-time policies in effect among private or public water works.

At our second committee meeting it was agreed that, at a later time, we should hold a joint meeting with the local sub-committee of the American Water Works Association Salary Committee.

So that the foundation work of our committee may be of value in the future, we have recommended that this Committee shall be made a Standing Committee, meeting annually or often, for the purpose of keeping the records up to date, thus meeting the changing trends as they develop, and providing a current file of wage bases and personnel policies for the use of the members of the Association.

It is obvious that the assignment of this Committee cannot be completed in much less than another year of committee work.

Respectfully submitted,

(*Signed*) WALTER C. CONROY
ROGER E. OAKMAN
ALLEN M. SYMONDS
WALTER B. BUSHWAY, *Chairman*

COMMITTEES OF THE NEW ENGLAND WATER WORKS ASSOCIATION 1945-46

Committee on Cathodic Protection of Steel Tanks and Standpipes: Donald C. Calderwood, *Chairman,* Richard H. Ellis, Harry U. Fuller, Madison H. Goff, William P. Melley, Sidney S. Anthony, and Howard Bailey.

Committee on Classification of Water Works Employees and Salaries: Walter B. Bushway, *Chairman,* Walter G. Conroy, Roger G. Oakman, George S. Ryan, and Allen M. Symonds.

Committee on Code for Pressure Piping (Joint with American Society of Mechanical Engineers): Thomas F. Wolfe.

Committee on Coefficients for Friction in Pipe Lines: Elson T. Killam, *Chairman,* Frank A. Barbour, and William W. Brush.

Committee on Committees: Warren J. Scott, *Chairman,* Thomas R. Camp, Harry U. Fuller, Arthur C. King, and Arthur L. Shaw.

Committee to Report on Developments in our Knowledge of Corrosion and its Mitigation: Edward M. Moore, *Chairman,* Lazarus Rubin, and Walton H. Sears.

Committee to Report on Developments in Water Quality Standards: Arthur D. Weston, *Chairman,* Almon L. Fales, and Melville C. Whipple.

Committee on Finances: Thomas R. Camp, *Chairman,* Philip J. Holton, Jr., and George G. Bean.

Committee on Gate Valves (Joint with American Water Works Association): Harold W. Griswold, *Chairman,* Leland G. Carlton and Walton H. Sears.

Committee on Hydrant Specifications (Joint with American Water Works Association): Roger W. Esty, *Chairman,* Harry U. Fuller, and Harold W. Griswold.

Committee to Investigate Grounding (Cooperating with the American Research Committee on Grounding): George A. Sampson, *Chairman,* Warren A. Gentner, Arthur V. Harrington, and Edward E. Minor.

Committee on Laying Cast-Iron Pipe (Joint with American Water Works Association): W. S. Mariner, *Chairman,* and Madison H. Goff.

Committee on Legislation: Arthur C. King, *Chairman,* Sidney S. Anthony, Theodore L. Bristol, Walter C. Conroy, Philip J. Holton, Jr., Percy R. Sanders, and Edward L. Tracy.

Committee on Library: E. Sherman Chase, *Chairman,* and Francis H. Kingsbury.

Committee on Membership: Francis H. Kingsbury, *Chairman,* Warren J. Scott, J. Elliott Hale, Leonard W. Trager. Edward L. Tracy, and Walter J. Shea.

Committee on Meter Specifications (Joint with American Water Works Association): Richard H. Ellis, *Chairman,* Warren A. Gentner, and D. H. Hall.

Committee on Northern New England Meeting (Preliminary arrangements): Donald C. Calderwood.

Committee on Southern New England Meeting (Preliminary arrangements): Arthur C. King.

Committee on Post War Activities (Joint with New England Sewage Works Association): E. Sherman Chase, *Chairman,* Theodore Cate, Richard H. Ellis, Harold W. Griswold, J. Elliott Hale, G. E. Hawkins, Philip J. Holton, Jr., Howard H. Potter, Fred J. Reny, Warren J. Scott, Walter J. Shea, Edward L. Tracy, and Arthur D. Weston.

Committee on Rainfall and Yield of Drainage Areas: Arthur D. Weston, *Chairman,* Harold K. Barrows, Allan T. Gifford, Richard S. Holmgren, Francis H. Kingsbury, Harvey B. Kinnison, Elbert E. Lochridge, Arthur T. Safford, Caleb M. Saville, Ralph M. Soule, Mfner R. Stackpole, and James L. Tighe.

Committee on Reciprocal Relations with the Institute of Water Engineers (England): E. Sherman Chase, *Chairman,* Leland G. Carlton, and Percy A. Shaw.

Committee on Reinforced Concrete Pressure Pipes (Joint with American Water Works Association): Stanley M. Dore, *Chairman,* and George A. Sampson.

Committee on Sluice Gates (Cooperating with Committee of American Water Works Association): William R. Conard, *Chairman,* and Harold W. Griswold.

Committee on Specifications for Cast-Iron Pipe and Special Castings (Sectional Committee under American Standard Association): William R. Conard and Arthur L. Shaw.

Committee on Specifications for Steel Pipe (Joint with American Water Works Association): Frank A. Barbour.

Committee on Standardization of Pipe Flanges and Fittings (Sectional Committee under American Standard Association): William R. Conard, *Chairman,* and Frank A. Barbour.

Committee on Steel Standpipes and Elevated Tanks (Joint with American Water Works Association): George A. Sampson, *Chairman,* Harry U. Fuller, and Henry E. Halpin.

Committee on Survey of Ground Water Supplies in New England: Leslie K. Sherman, *Chairman,* Joseph C. Knox, Howard H. Potter, Walter J. Shea, Edward L. Tracy, and Leonard Trager.

Committee on Survival and Retirement Experience with Water Works Facilities (Joint with American Water Works Association): Reeves Newsom, *Chairman,* Harry U. Fuller, and Thomas H. Wiggin.

Committee on Technical Program: Stanley M. Dore, *Chairman,* Joseph A. McCarthy, Roger G. Oakman, Frederick O. A. Almquist, Thomas R. Camp, Gordon M. Fair, J. Elliott Hale, and Paul F. Howard.

Committee on Technical Specifications from Joint Committees: Arthur L. Shaw, *Chairman,* and Karl R. Kennison.

Committee on Threads for Underground Service Lines (Joint with American Water Works Association): William W. Brush, *Chairman,* and Donald C. Calderwood.

Committee on Valve Box Frames and Covers (Joint with American Water Works Association): Sidney S. Anthony, *Chairman,* and Scott Keith.

Committee on Wartime Activities (Joint with American Water Works Association): Sidney S. Anthony, *Chairman,* and Fred S. Gibbs.

Committee on Water and Sewage Works Development (Joint with American Water Works Association, Federation of Sewage Works Associations, and Water and Sewage Works Manufacturers Association): E. Sherman Chase, *Chairman,* and Roger W. Esty.

Committee on Water Tolerances for Industrial Uses: Edward W. Moore, *Chairman,* Stuart E. Coburn, Louis A. Olney, Hervey J. Skinner, and George A. Sampson.